

PUBLIC LECTURE SERIES



Astronomy vs Astrology:  
What's the Difference, Really?

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Featuring Guest Speaker:  
Nicole Arulanantham

1  
00:00:06,869 --> 00:00:05,430  
welcome to the space telescope public

2  
00:00:10,150 --> 00:00:06,879  
lecture series

3  
00:00:14,910 --> 00:00:10,160  
tonight astronomy versus astrology

4  
00:00:19,349 --> 00:00:17,430  
arlanathan i'm your host dr frank

5  
00:00:21,590 --> 00:00:19,359  
summers of the space telescope science

6  
00:00:23,910 --> 00:00:21,600  
institute and i want to thank our

7  
00:00:27,109 --> 00:00:23,920  
wonderful tech team that brings this to

8  
00:00:29,509 --> 00:00:27,119  
you live over the internet thomas marufu

9  
00:00:32,310 --> 00:00:29,519  
and grant justice

10  
00:00:34,790 --> 00:00:32,320  
in our upcoming talks we only have one

11  
00:00:36,709 --> 00:00:34,800  
scheduled right now but don't worry i

12  
00:00:38,310 --> 00:00:36,719  
will get the other one scheduled it's

13  
00:00:40,150 --> 00:00:38,320

just that you know during summer break

14

00:00:43,990 --> 00:00:40,160

is a hard time to get people scheduled

15

00:00:46,790 --> 00:00:44,000

so we have for you todd lauer of nsf's

16

00:00:48,950 --> 00:00:46,800

noir lab that sounds really cool but

17

00:00:50,470 --> 00:00:48,960

it's the national optical and infrared

18

00:00:52,709 --> 00:00:50,480

laboratory

19

00:00:57,110 --> 00:00:52,719

and he'll be talking about an amazing

20

00:00:59,830 --> 00:00:57,120

discovery on how dark is space what is

21

00:01:02,069 --> 00:00:59,840

the depth that you can go to and really

22

00:01:04,549 --> 00:01:02,079

see the faintest darkest thing there are

23

00:01:07,030 --> 00:01:04,559

well you got to measure it not from

24

00:01:09,030 --> 00:01:07,040

where we are in the solar system but

25

00:01:10,390 --> 00:01:09,040

at the edge of the solar system it's a

26

00:01:13,510 --> 00:01:10,400

really cool measurement and he'll tell

27

00:01:15,429 --> 00:01:13,520

you about that in october uh in november

28

00:01:17,749 --> 00:01:15,439

and december we will have an amazing

29

00:01:21,350 --> 00:01:17,759

speaker for you that i promise i will

30

00:01:23,190 --> 00:01:21,360

get this i'll get scheduled this month

31

00:01:28,149 --> 00:01:23,200

when i do have them schedules you can

32

00:01:33,270 --> 00:01:31,030

public hyphen lectures or if you just

33

00:01:35,510 --> 00:01:33,280

put in space telescope public lectures

34

00:01:37,749 --> 00:01:35,520

series in your favorite search engine

35

00:01:39,510 --> 00:01:37,759

you'll come up with this page

36

00:01:41,749 --> 00:01:39,520

and on the left side of this page you

37

00:01:44,550 --> 00:01:41,759

can see that we have our link to our

38

00:01:46,870 --> 00:01:44,560

webcast both our youtube playlist

39

00:01:49,109 --> 00:01:46,880

and our webcast archive at the space

40

00:01:51,429 --> 00:01:49,119

telescope science institute

41

00:01:54,069 --> 00:01:51,439

on the right hand side you can see the

42

00:01:56,709 --> 00:01:54,079

email subscription box just enter your

43

00:01:59,109 --> 00:01:56,719

email address hit subscribe and you'll

44

00:02:00,950 --> 00:01:59,119

get our monthly emails

45

00:02:03,350 --> 00:02:00,960

also on that web page you will find a

46

00:02:05,429 --> 00:02:03,360

list of all the upcoming lectures

47

00:02:08,630 --> 00:02:05,439

and if you read more about each of the

48

00:02:10,630 --> 00:02:08,640

lectures you will find the

49

00:02:12,869 --> 00:02:10,640

speaker and title you will find the

50

00:02:14,309 --> 00:02:12,879

abstract about it and after it has

51  
00:02:17,430 --> 00:02:14,319  
happened you'll see the links to the

52  
00:02:21,190 --> 00:02:17,440  
sdsci webcast as well as the youtube

53  
00:02:25,190 --> 00:02:23,589  
for email announcements well i've

54  
00:02:27,670 --> 00:02:25,200  
already told you the easiest thing to do

55  
00:02:30,710 --> 00:02:27,680  
is to sign up at our website you can

56  
00:02:32,309 --> 00:02:30,720  
also subscribe to our youtube channel

57  
00:02:34,790 --> 00:02:32,319  
youtube.com

58  
00:02:36,710 --> 00:02:34,800  
all one word hubble space telescope all

59  
00:02:39,430 --> 00:02:36,720  
right that will find you all of our

60  
00:02:41,430 --> 00:02:39,440  
videos and if you sign if you hit the

61  
00:02:44,229 --> 00:02:41,440  
subscribe button you will get the new

62  
00:02:45,430 --> 00:02:44,239  
video notices and reminders of our live

63  
00:02:46,949 --> 00:02:45,440

events

64

00:02:49,509 --> 00:02:46,959

finally if you have comments for

65

00:02:52,920 --> 00:02:49,519

questions you can send them to the email

66

00:02:54,869 --> 00:02:52,930

address public lecture at sdsci.edu

67

00:02:57,509 --> 00:02:54,879

[Music]

68

00:03:00,149 --> 00:02:57,519

on social media you can find our

69

00:03:01,750 --> 00:03:00,159

institute for the hubble space telescope

70

00:03:03,990 --> 00:03:01,760

for the upcoming james webb space

71

00:03:07,110 --> 00:03:04,000

telescope and for the space telescope

72

00:03:09,430 --> 00:03:07,120

science institute on facebook twitter

73

00:03:10,790 --> 00:03:09,440

youtube and instagram at the address is

74

00:03:13,509 --> 00:03:10,800

provided here

75

00:03:15,670 --> 00:03:13,519

myself i do a tiny bit of social media

76  
00:03:19,830 --> 00:03:15,680  
um you can find me as dr prank summers

77  
00:03:22,070 --> 00:03:19,840  
on both facebook and twitter

78  
00:03:25,670 --> 00:03:22,080  
and now our news from the universe for

79  
00:03:27,270 --> 00:03:25,680  
september 2021

80  
00:03:29,030 --> 00:03:27,280  
our first story

81  
00:03:30,789 --> 00:03:29,040  
celebrity breakups

82  
00:03:32,949 --> 00:03:30,799  
comet style

83  
00:03:35,509 --> 00:03:32,959  
now if you pay attention to the gossip

84  
00:03:37,589 --> 00:03:35,519  
magazines you hear a lot about celebrity

85  
00:03:39,110 --> 00:03:37,599  
breakups and they seem to go they get

86  
00:03:40,710 --> 00:03:39,120  
they break up and they get back together

87  
00:03:43,589 --> 00:03:40,720  
and they break up and it seems to go on

88  
00:03:46,710 --> 00:03:43,599

forever well i gotta tell you they got

89

00:03:49,990 --> 00:03:46,720

nothing on comments okay and so let's

90

00:03:52,550 --> 00:03:50,000

talk about comet breakups and this is

91

00:03:54,910 --> 00:03:52,560

comet atlas and it's in the middle of a

92

00:03:57,589 --> 00:03:54,920

severe breakup matter of fact it's

93

00:03:58,470 --> 00:03:57,599

disintegrating and going to pieces all

94

00:04:00,949 --> 00:03:58,480

right

95

00:04:03,429 --> 00:04:00,959

this is as hubble observed it on april

96

00:04:05,350 --> 00:04:03,439

23rd 2020.

97

00:04:07,670 --> 00:04:05,360

and you might say okay yeah the comet is

98

00:04:09,589 --> 00:04:07,680

broken up and that that's that's the big

99

00:04:11,670 --> 00:04:09,599

story that the comet breaks into all

100

00:04:14,710 --> 00:04:11,680

these pieces and the pieces disintegrate

101  
00:04:17,270 --> 00:04:14,720  
but there's a lot more to this story

102  
00:04:19,670 --> 00:04:17,280  
you see because comet atlas

103  
00:04:22,629 --> 00:04:19,680  
when it was discovered was found to have

104  
00:04:25,430 --> 00:04:22,639  
the same orbital trajectory as the great

105  
00:04:27,510 --> 00:04:25,440  
comet of 1844.

106  
00:04:29,430 --> 00:04:27,520  
now i also have to say i'm lying to you

107  
00:04:32,870 --> 00:04:29,440  
with this picture this picture is

108  
00:04:36,070 --> 00:04:32,880  
actually of the great comet of 1843

109  
00:04:38,790 --> 00:04:36,080  
uh because i couldn't find a uh picture

110  
00:04:40,950 --> 00:04:38,800  
of the great comet of 1844.

111  
00:04:42,710 --> 00:04:40,960  
uh turns out there was great comets in

112  
00:04:45,510 --> 00:04:42,720  
two years in a row

113  
00:04:48,790 --> 00:04:45,520

they had a really good run in the 1840s

114

00:04:51,350 --> 00:04:48,800

all right and so the two comets have the

115

00:04:52,870 --> 00:04:51,360

same orbit and they did the mathematics

116

00:04:55,830 --> 00:04:52,880

and they pulled it back and they said

117

00:04:58,469 --> 00:04:55,840

well what probably happened so this is a

118

00:05:01,830 --> 00:04:58,479

much larger story of the breakup and it

119

00:05:04,230 --> 00:05:01,840

starts five thousand years ago so around

120

00:05:06,469 --> 00:05:04,240

five thousand years ago a comet passed

121

00:05:08,710 --> 00:05:06,479

by the sun and you can see this little

122

00:05:10,790 --> 00:05:08,720

comet doohickey that i've drawn here on

123

00:05:13,749 --> 00:05:10,800

the left hand side of the screen

124

00:05:15,990 --> 00:05:13,759

and after it passed by the sun the comet

125

00:05:18,150 --> 00:05:16,000

broke into two pieces

126

00:05:20,950 --> 00:05:18,160

two relatively large pieces and those

127

00:05:21,749 --> 00:05:20,960

pieces had just a slightly velocity kick

128

00:05:23,990 --> 00:05:21,759

okay

129

00:05:27,189 --> 00:05:24,000

one was moving just a tiny bit slower

130

00:05:29,510 --> 00:05:27,199

than the other and when it broke apart

131

00:05:32,390 --> 00:05:29,520

and over the 5 000 years that it was

132

00:05:34,230 --> 00:05:32,400

orbiting these pieces slowly drifted

133

00:05:37,029 --> 00:05:34,240

apart they stayed on basically the same

134

00:05:39,350 --> 00:05:37,039

orbit but they pulled a

135

00:05:41,029 --> 00:05:39,360

further and further apart

136

00:05:45,029 --> 00:05:41,039

the first piece

137

00:05:48,230 --> 00:05:45,039

the bigger piece arrived in 1844 as the

138

00:05:50,390 --> 00:05:48,240

great comet of 1844.

139

00:05:54,710 --> 00:05:50,400

the second piece didn't arrive till

140

00:05:55,670 --> 00:05:54,720

almost 200 years later in 2020 as comet

141

00:05:58,710 --> 00:05:55,680

atlas

142

00:06:01,189 --> 00:05:58,720

and as that piece arrived this is the

143

00:06:03,270 --> 00:06:01,199

one that disintegrated and

144

00:06:05,830 --> 00:06:03,280

so you may think that the celebrity

145

00:06:07,990 --> 00:06:05,840

breakups take forever but this one shows

146

00:06:11,110 --> 00:06:08,000

you that comet breakups can actually

147

00:06:13,110 --> 00:06:11,120

last 5 000 years

148

00:06:14,309 --> 00:06:13,120

scientifically what do we learn about

149

00:06:17,110 --> 00:06:14,319

this

150

00:06:20,070 --> 00:06:17,120

well we really when when the comet

151  
00:06:22,710 --> 00:06:20,080  
breaks up you actually under expose the

152  
00:06:24,710 --> 00:06:22,720  
interior of the comet and so the

153  
00:06:27,189 --> 00:06:24,720  
question is is the

154  
00:06:29,510 --> 00:06:27,199  
interior of a comet a uniform structure

155  
00:06:31,670 --> 00:06:29,520  
or is it lumpy and if it's lumpy on what

156  
00:06:33,350 --> 00:06:31,680  
scale is it lumpy all right and so you

157  
00:06:35,350 --> 00:06:33,360  
study questions like how many fragments

158  
00:06:36,950 --> 00:06:35,360  
and comets did it break into

159  
00:06:38,629 --> 00:06:36,960  
what is the size distribution of the

160  
00:06:40,309 --> 00:06:38,639  
fragments from the tiny pieces to the

161  
00:06:42,469 --> 00:06:40,319  
very large pieces

162  
00:06:44,710 --> 00:06:42,479  
and how far from the sun do these

163  
00:06:46,790 --> 00:06:44,720

fragments disintegrate how much solar

164

00:06:50,870 --> 00:06:46,800

radiation is necessary to cause them to

165

00:06:53,189 --> 00:06:50,880

break apart and furthermore how long do

166

00:06:55,189 --> 00:06:53,199

fragments take to disintegrate

167

00:06:57,110 --> 00:06:55,199

what is the density structure of these

168

00:06:59,830 --> 00:06:57,120

fragments do they disintegrate quickly

169

00:07:01,589 --> 00:06:59,840

to disintegrate slowly and in particular

170

00:07:02,390 --> 00:07:01,599

if you have two fragments of the same

171

00:07:04,469 --> 00:07:02,400

size

172

00:07:05,830 --> 00:07:04,479

do they both disintegrate in the same

173

00:07:07,749 --> 00:07:05,840

amount of time

174

00:07:09,670 --> 00:07:07,759

so the astronomers have been studying

175

00:07:11,430 --> 00:07:09,680

this here are two images of comet

176

00:07:13,430 --> 00:07:11,440

athletes breakup

177

00:07:14,390 --> 00:07:13,440

and their conclusion based on common

178

00:07:17,830 --> 00:07:14,400

atlas

179

00:07:20,070 --> 00:07:17,840

is that even very small comets can have

180

00:07:21,749 --> 00:07:20,080

lumpy interiors

181

00:07:24,469 --> 00:07:21,759

they suspect the parent body for this

182

00:07:26,710 --> 00:07:24,479

was less than one kilometer across

183

00:07:28,070 --> 00:07:26,720

and so even comets as small as one

184

00:07:31,430 --> 00:07:28,080

kilometer across

185

00:07:35,990 --> 00:07:31,440

can have lumpy interiors and that's what

186

00:07:40,230 --> 00:07:37,990

our second story

187

00:07:42,790 --> 00:07:40,240

ngc 2276

188

00:07:45,749 --> 00:07:42,800

you're pulling my arm

189

00:07:48,790 --> 00:07:45,759

now this is of course a variation on the

190

00:07:50,790 --> 00:07:48,800

phrase you're pulling my leg but

191

00:07:53,670 --> 00:07:50,800

galaxies don't have legs

192

00:07:57,189 --> 00:07:53,680

they do however have arms especially

193

00:08:01,350 --> 00:07:57,199

when they are a spiral galaxy these are

194

00:08:05,510 --> 00:08:01,360

three gorgeous spiral galaxies ngc 1232

195

00:08:06,869 --> 00:08:05,520

the whirlpool galaxy and ngc 3982 and

196

00:08:10,150 --> 00:08:06,879

one of the things you see is the

197

00:08:12,550 --> 00:08:10,160

beautiful symmetry of these spiral arms

198

00:08:13,909 --> 00:08:12,560

that makes these spiral galaxies just so

199

00:08:16,550 --> 00:08:13,919

gorgeous

200

00:08:18,309 --> 00:08:16,560

well a recent observation from hubble

201  
00:08:22,230 --> 00:08:18,319  
looked at a galaxy a spiral galaxy

202  
00:08:24,150 --> 00:08:22,240  
called ngc 2276

203  
00:08:25,110 --> 00:08:24,160  
and here you see those beautiful spiral

204  
00:08:28,790 --> 00:08:25,120  
arms

205  
00:08:30,790 --> 00:08:28,800  
but you also see a bit of asymmetry

206  
00:08:33,350 --> 00:08:30,800  
there's something not quite even the

207  
00:08:34,949 --> 00:08:33,360  
pattern isn't smooth rounded

208  
00:08:36,949 --> 00:08:34,959  
so what's going on

209  
00:08:39,670 --> 00:08:36,959  
well to answer that let's look on a

210  
00:08:40,550 --> 00:08:39,680  
larger scale this is an image from adam

211  
00:08:44,630 --> 00:08:40,560  
block

212  
00:08:49,030 --> 00:08:44,640  
and uh you can see that ngc 2276

213  
00:08:53,269 --> 00:08:49,040

is nearby galaxy ngc 2300

214

00:08:55,350 --> 00:08:53,279

and the gravity of ngc 2300 is pouring

215

00:08:57,269 --> 00:08:55,360

on engine c2276

216

00:08:59,910 --> 00:08:57,279

and it's pulling stronger on the near

217

00:09:01,350 --> 00:08:59,920

side than it is on the far side

218

00:09:04,310 --> 00:09:01,360

producing

219

00:09:06,870 --> 00:09:04,320

a pull on the spiral arm on the near

220

00:09:09,190 --> 00:09:06,880

side of 2276.

221

00:09:11,430 --> 00:09:09,200

and this image also includes hydrogen

222

00:09:12,949 --> 00:09:11,440

alpha which shows you where the star

223

00:09:14,870 --> 00:09:12,959

forming regions are

224

00:09:18,310 --> 00:09:14,880

and you'll notice in the upper left of

225

00:09:20,150 --> 00:09:18,320

ngc 2276 there's enhanced star formation

226

00:09:22,389 --> 00:09:20,160

there's a lot of star formation

227

00:09:24,150 --> 00:09:22,399

happening and really that shouldn't

228

00:09:26,630 --> 00:09:24,160

happen in just one part of the galaxy it

229

00:09:28,949 --> 00:09:26,640

should happen uh relatively all over

230

00:09:31,590 --> 00:09:28,959

when you have a star from the galaxy so

231

00:09:33,190 --> 00:09:31,600

this indicates that perhaps

232

00:09:35,990 --> 00:09:33,200

the galaxy is

233

00:09:38,790 --> 00:09:36,000

running through an intergalactic medium

234

00:09:42,470 --> 00:09:38,800

and that there is pressure pushing on

235

00:09:43,269 --> 00:09:42,480

these stars to create star formation

236

00:09:47,190 --> 00:09:43,279

so

237

00:09:48,389 --> 00:09:47,200

the asymmetry in ngc 2276 on the right

238

00:09:50,389 --> 00:09:48,399

hand side

239

00:09:53,030 --> 00:09:50,399

is caused by the gravitational tidal

240

00:09:56,310 --> 00:09:53,040

pole of ngc 2300

241

00:09:58,550 --> 00:09:56,320

and on the left hand side perhaps by ram

242

00:10:00,630 --> 00:09:58,560

pressure compression as it's moving

243

00:10:02,230 --> 00:10:00,640

through this intergalactic medium

244

00:10:04,150 --> 00:10:02,240

you'll notice i put a question mark

245

00:10:06,550 --> 00:10:04,160

there because it's not really proven

246

00:10:09,509 --> 00:10:06,560

that it is ram pressure compression but

247

00:10:11,990 --> 00:10:09,519

it looks like one of the good good uh

248

00:10:14,710 --> 00:10:12,000

explanations for it now and people will

249

00:10:16,310 --> 00:10:14,720

of course uh study it more in order to

250

00:10:19,110 --> 00:10:16,320

figure out that's true

251  
00:10:21,110 --> 00:10:19,120  
but this is a galaxy where hey you know

252  
00:10:24,069 --> 00:10:21,120  
it's not lying to you it's not pulling

253  
00:10:28,230 --> 00:10:24,079  
your your leg uh but another galaxy is

254  
00:10:33,430 --> 00:10:31,750  
our speaker tonight uh is nicole

255  
00:10:35,509 --> 00:10:33,440  
arulanatham

256  
00:10:37,590 --> 00:10:35,519  
and she will be talking on astronomy

257  
00:10:40,470 --> 00:10:37,600  
versus astrology

258  
00:10:42,069 --> 00:10:40,480  
now nicole is relatively new at the

259  
00:10:44,710 --> 00:10:42,079  
space telescope science institute she's

260  
00:10:47,030 --> 00:10:44,720  
only been there for one year which gives

261  
00:10:48,790 --> 00:10:47,040  
her a special distinction of

262  
00:10:50,790 --> 00:10:48,800  
she's been working at space telescope

263  
00:10:52,949 --> 00:10:50,800

and she's never had an office at space

264

00:10:55,350 --> 00:10:52,959

telescope because we've been in work

265

00:10:57,990 --> 00:10:55,360

from home for the past year

266

00:11:01,990 --> 00:10:58,000

uh before she came to space telescope

267

00:11:04,790 --> 00:11:02,000

she did her um phd at the colorado

268

00:11:06,230 --> 00:11:04,800

university colorado boulder which is cu

269

00:11:08,790 --> 00:11:06,240

boulder she corrected me even though you

270

00:11:11,110 --> 00:11:08,800

would think it would be uc boulder

271

00:11:13,790 --> 00:11:11,120

and she will not be talking on her

272

00:11:16,069 --> 00:11:13,800

thesis subject but she works on

273

00:11:17,910 --> 00:11:16,079

proto-planetary disks

274

00:11:21,509 --> 00:11:17,920

before that she did her master's at

275

00:11:24,949 --> 00:11:21,519

wesleyan um and her uh undergraduate

276

00:11:28,550 --> 00:11:24,959

work at ucla

277

00:11:30,949 --> 00:11:28,560

uh nicole in her spare time likes to run

278

00:11:33,670 --> 00:11:30,959

and she has joined a local group called

279

00:11:35,910 --> 00:11:33,680

a tribe called run

280

00:11:40,150 --> 00:11:35,920

oh so ladies and gentlemen please

281

00:11:44,710 --> 00:11:42,150

thank you frank can you see and hear me

282

00:11:47,430 --> 00:11:45,670

yes

283

00:11:49,190 --> 00:11:47,440

okay awesome

284

00:11:51,269 --> 00:11:49,200

so thank you all so much for joining i'm

285

00:11:53,509 --> 00:11:51,279

really thrilled to be here and giving

286

00:11:56,069 --> 00:11:53,519

you the public lecture tonight

287

00:11:59,350 --> 00:11:56,079

um so as you can see on this title slide

288

00:12:01,350 --> 00:11:59,360

our main question tonight is going to be

289

00:12:02,230 --> 00:12:01,360

understanding what the difference is

290

00:12:06,150 --> 00:12:02,240

really

291

00:12:08,550 --> 00:12:06,160

between astronomy and astrology

292

00:12:11,430 --> 00:12:08,560

now if we were able to have this lecture

293

00:12:13,829 --> 00:12:11,440

in person i would maybe ask for some

294

00:12:16,550 --> 00:12:13,839

audience participation at this point

295

00:12:19,190 --> 00:12:16,560

so i might take a quick poll

296

00:12:21,750 --> 00:12:19,200

and ask everyone in the audience to

297

00:12:23,750 --> 00:12:21,760

raise their hands if they feel confident

298

00:12:24,949 --> 00:12:23,760

that they can answer this question right

299

00:12:27,190 --> 00:12:24,959

now

300

00:12:29,590 --> 00:12:27,200

so without hearing the rest of the talk

301

00:12:31,590 --> 00:12:29,600

i would ask who feels like they can tell

302

00:12:33,910 --> 00:12:31,600

me the difference between astronomy and

303

00:12:35,910 --> 00:12:33,920

astrology

304

00:12:38,069 --> 00:12:35,920

and if we had a really engaged audience

305

00:12:40,150 --> 00:12:38,079

we might see a lot of hands go up all

306

00:12:41,910 --> 00:12:40,160

across the room

307

00:12:44,629 --> 00:12:41,920

so i would maybe pick on a few people

308

00:12:46,949 --> 00:12:44,639

who looked particularly confident

309

00:12:49,030 --> 00:12:46,959

and i would ask them to tell us in maybe

310

00:12:50,949 --> 00:12:49,040

two or three sentences

311

00:12:52,949 --> 00:12:50,959

what the difference is between astronomy

312

00:12:55,030 --> 00:12:52,959

and astrology

313

00:12:56,710 --> 00:12:55,040

now maybe we would have some rock star

314

00:12:59,190 --> 00:12:56,720

participants in the audience who could

315

00:13:00,790 --> 00:12:59,200

give us a perfect beautiful answer that

316

00:13:02,470 --> 00:13:00,800

would be really embarrassing for me

317

00:13:04,150 --> 00:13:02,480

because then i still have to give this

318

00:13:06,550 --> 00:13:04,160

talk which is maybe pointless if

319

00:13:08,230 --> 00:13:06,560

somebody can already answer it

320

00:13:09,350 --> 00:13:08,240

but i think what would more likely

321

00:13:11,750 --> 00:13:09,360

happen

322

00:13:15,509 --> 00:13:11,760

would be that people would be

323

00:13:18,790 --> 00:13:15,519

really good at describing astronomy

324

00:13:20,550 --> 00:13:18,800

or really good at describing astrology

325

00:13:22,710 --> 00:13:20,560

and i think we would have a really hard

326

00:13:26,069 --> 00:13:22,720

time comparing the two

327

00:13:28,150 --> 00:13:26,079

without using language like nonsense

328

00:13:29,269 --> 00:13:28,160

or rocket science

329

00:13:31,509 --> 00:13:29,279

so that's what we're really going to

330

00:13:33,750 --> 00:13:31,519

dive into tonight

331

00:13:35,430 --> 00:13:33,760

now you may be asking yourselves why is

332

00:13:37,590 --> 00:13:35,440

she so confident that this is a hard

333

00:13:41,189 --> 00:13:37,600

question to answer

334

00:13:43,750 --> 00:13:41,199

well the confusion between astronomy and

335

00:13:44,949 --> 00:13:43,760

astrology is really prevalent in our

336

00:13:47,189 --> 00:13:44,959

society

337

00:13:49,269 --> 00:13:47,199

and a couple of years ago there was a

338

00:13:52,470 --> 00:13:49,279

really perfect case study that

339

00:13:53,269 --> 00:13:52,480

demonstrated this confusion

340

00:13:58,150 --> 00:13:53,279

so

341

00:13:59,910 --> 00:13:58,160

bachelor and bachelorette tv shows

342

00:14:01,750 --> 00:13:59,920

but i hadn't really thought too much

343

00:14:02,870 --> 00:14:01,760

about the australian edition of the

344

00:14:04,790 --> 00:14:02,880

bachelor

345

00:14:07,430 --> 00:14:04,800

until 2019

346

00:14:08,710 --> 00:14:07,440

when the show cast an astrophysicist dr

347

00:14:10,710 --> 00:14:08,720

matt agnew

348

00:14:13,670 --> 00:14:10,720

as the bachelor

349

00:14:16,710 --> 00:14:13,680

now matt was going to be introduced to a

350

00:14:18,470 --> 00:14:16,720

whole group of single women

351

00:14:20,550 --> 00:14:18,480

and he would get to go on dates with

352

00:14:22,389 --> 00:14:20,560

them over the course of the show he

353

00:14:24,150 --> 00:14:22,399

would hand out roses to the ones that he

354

00:14:25,910 --> 00:14:24,160

really felt a connection with and by the

355

00:14:28,550 --> 00:14:25,920

end of the show he would have narrowed

356

00:14:31,269 --> 00:14:28,560

it down to his one true love lots of

357

00:14:32,230 --> 00:14:31,279

drama would ensue throughout the show

358

00:14:33,430 --> 00:14:32,240

and

359

00:14:36,550 --> 00:14:33,440

you know we would be left with a

360

00:14:38,389 --> 00:14:36,560

beautiful happily ever after

361

00:14:40,470 --> 00:14:38,399

now the reason that the Australian

362

00:14:42,629 --> 00:14:40,480

audition edition of the show came across

363

00:14:44,949 --> 00:14:42,639

my radar was because they released what

364

00:14:46,790 --> 00:14:44,959

was a very controversial promotional

365

00:14:50,389 --> 00:14:46,800

video

366

00:14:53,030 --> 00:14:50,399

abby

367

00:14:55,110 --> 00:14:53,040

come up to matt to introduce herself and

368

00:14:56,310 --> 00:14:55,120

she says hello and then asks what do you

369

00:14:57,910 --> 00:14:56,320

do

370

00:14:59,509 --> 00:14:57,920

to which matt replies oh i'm an

371

00:15:01,750 --> 00:14:59,519

astrophysicist

372

00:15:05,269 --> 00:15:01,760

and we have a slight pause

373

00:15:07,590 --> 00:15:05,279

to which abby replies okay i'm a gemini

374

00:15:10,150 --> 00:15:07,600

and then all of a sudden the music

375

00:15:13,189 --> 00:15:10,160

changes it gets very dramatic we can

376  
00:15:14,069 --> 00:15:13,199  
tell that abby has made a huge blunder

377  
00:15:15,509 --> 00:15:14,079  
here

378  
00:15:17,990 --> 00:15:15,519  
because we see matt looking

379  
00:15:19,509 --> 00:15:18,000  
flabbergasted he takes a very long time

380  
00:15:21,269 --> 00:15:19,519  
to respond

381  
00:15:23,350 --> 00:15:21,279  
so it's clear that something has gone

382  
00:15:25,670 --> 00:15:23,360  
wrong in this interaction abby has made

383  
00:15:28,310 --> 00:15:25,680  
a mistake

384  
00:15:31,350 --> 00:15:28,320  
now then the music changes again it

385  
00:15:34,629 --> 00:15:31,360  
becomes a little bit more bubbly and fun

386  
00:15:36,710 --> 00:15:34,639  
and we see some clips of the women

387  
00:15:38,949 --> 00:15:36,720  
talking inside the house after they've

388  
00:15:40,550 --> 00:15:38,959

introduced themselves to the bachelor so

389

00:15:42,230 --> 00:15:40,560

we hear somebody say that it sounds like

390

00:15:44,069 --> 00:15:42,240

a fake job like my boyfriend's an

391

00:15:47,030 --> 00:15:44,079

astrophysicist

392

00:15:48,629 --> 00:15:47,040

off camera we hear a producer ask

393

00:15:50,870 --> 00:15:48,639

another contestant whether she

394

00:15:52,790 --> 00:15:50,880

understands what matt's job is

395

00:15:55,910 --> 00:15:52,800

to which she replies

396

00:15:58,470 --> 00:15:55,920

no not really am i supposed to

397

00:16:00,790 --> 00:15:58,480

and to ask to answer her question

398

00:16:03,590 --> 00:16:00,800

not necessarily right we don't all need

399

00:16:05,269 --> 00:16:03,600

to know everything about everyone that

400

00:16:07,829 --> 00:16:05,279

we might meet

401  
00:16:11,269 --> 00:16:07,839  
uh but it's worth noting that these

402  
00:16:13,030 --> 00:16:11,279  
women were absolutely skewered on social

403  
00:16:14,069 --> 00:16:13,040  
media

404  
00:16:15,829 --> 00:16:14,079  
now i'm going to give you a little bit

405  
00:16:17,910 --> 00:16:15,839  
of behind the scenes information that

406  
00:16:19,110 --> 00:16:17,920  
came out in interviews after the show

407  
00:16:21,910 --> 00:16:19,120  
aired

408  
00:16:25,509 --> 00:16:21,920  
our lovely gemini abby and the bachelor

409  
00:16:28,069 --> 00:16:25,519  
mat both shared that their conversation

410  
00:16:30,389 --> 00:16:28,079  
where abby said that she was a gemini

411  
00:16:32,790 --> 00:16:30,399  
went very differently in real life

412  
00:16:35,269 --> 00:16:32,800  
and that the producers of the show had

413  
00:16:38,069 --> 00:16:35,279

actually pieced together

414

00:16:40,150 --> 00:16:38,079

uh clips of what she had said to make it

415

00:16:41,350 --> 00:16:40,160

look like she had responded that she was

416

00:16:42,949 --> 00:16:41,360

a gemini

417

00:16:45,189 --> 00:16:42,959

when matt told her that she was an

418

00:16:47,829 --> 00:16:45,199

astrophysicist

419

00:16:50,150 --> 00:16:47,839

so this is very interesting for a couple

420

00:16:52,470 --> 00:16:50,160

of reasons so first of all if abby

421

00:16:54,069 --> 00:16:52,480

really had gotten confused

422

00:16:56,069 --> 00:16:54,079

that's something that's really prevalent

423

00:16:58,629 --> 00:16:56,079

in society so she's not out of the

424

00:17:01,110 --> 00:16:58,639

ordinary here

425

00:17:03,189 --> 00:17:01,120

but if this was true that the producers

426  
00:17:05,350 --> 00:17:03,199  
of the show had cut and pasted these

427  
00:17:06,949 --> 00:17:05,360  
clips to make it look like she had

428  
00:17:08,870 --> 00:17:06,959  
gotten confused

429  
00:17:10,390 --> 00:17:08,880  
it's clearly done in a way to make us

430  
00:17:12,150 --> 00:17:10,400  
feel some type of way about the

431  
00:17:13,990 --> 00:17:12,160  
contestants that might influence our

432  
00:17:16,150 --> 00:17:14,000  
perception of them moving forward and

433  
00:17:18,150 --> 00:17:16,160  
watching the rest of the show

434  
00:17:19,909 --> 00:17:18,160  
and so it's clear that not only is this

435  
00:17:22,230 --> 00:17:19,919  
confusion prevalent

436  
00:17:25,590 --> 00:17:22,240  
people know that this confusion is

437  
00:17:28,470 --> 00:17:25,600  
prevalent and are very much inclined to

438  
00:17:30,070 --> 00:17:28,480

use it as a way to entertain

439

00:17:32,070 --> 00:17:30,080

rather than correcting some of the

440

00:17:34,470 --> 00:17:32,080

misconceptions or answering some of the

441

00:17:38,230 --> 00:17:34,480

very reasonable questions that the women

442

00:17:41,510 --> 00:17:39,909

now it was clear from watching the video

443

00:17:43,990 --> 00:17:41,520

that we were supposed to think a certain

444

00:17:45,750 --> 00:17:44,000

type of way about the intelligence of

445

00:17:46,789 --> 00:17:45,760

these women

446

00:17:48,549 --> 00:17:46,799

and so

447

00:17:50,549 --> 00:17:48,559

in the interest of working smarter and

448

00:17:51,590 --> 00:17:50,559

not harder before we really dive into

449

00:17:53,590 --> 00:17:51,600

the talk

450

00:17:56,390 --> 00:17:53,600

we can see whether an animal an

451  
00:17:58,950 --> 00:17:56,400  
etymology lesson will clear things up

452  
00:18:02,310 --> 00:17:58,960  
so we'll break down the words into their

453  
00:18:04,549 --> 00:18:02,320  
components and see if we can get some

454  
00:18:06,230 --> 00:18:04,559  
definitions out of that that maybe these

455  
00:18:07,510 --> 00:18:06,240  
women should have been able to figure

456  
00:18:09,750 --> 00:18:07,520  
out

457  
00:18:11,830 --> 00:18:09,760  
so we'll start with our prefix astro

458  
00:18:14,470 --> 00:18:11,840  
which is common to astronomy

459  
00:18:16,950 --> 00:18:14,480  
astrophysics and astrology

460  
00:18:19,990 --> 00:18:16,960  
and we know that the prefix astro tells

461  
00:18:24,310 --> 00:18:20,000  
us that something is related to stars

462  
00:18:28,150 --> 00:18:24,320  
celestial bodies and outer space

463  
00:18:30,710 --> 00:18:28,160

then we'll take a look at our suffixes

464

00:18:33,909 --> 00:18:30,720

the suffix anatomy tells us about a

465

00:18:36,150 --> 00:18:33,919

system of rules laws or knowledge about

466

00:18:39,029 --> 00:18:36,160

a particular field

467

00:18:41,990 --> 00:18:39,039

the suffix physics tells us about nature

468

00:18:44,950 --> 00:18:42,000

or natural order

469

00:18:48,870 --> 00:18:44,960

and finally the suffix ology tells us

470

00:18:50,470 --> 00:18:48,880

about a field of study or a discipline

471

00:18:52,230 --> 00:18:50,480

so we have our breakdown we know what

472

00:18:54,070 --> 00:18:52,240

our prefix means and we know what our

473

00:18:56,310 --> 00:18:54,080

three suffixes mean

474

00:18:57,909 --> 00:18:56,320

so let's stick them all together and see

475

00:18:59,750 --> 00:18:57,919

if we can get some meaning out of these

476

00:19:01,990 --> 00:18:59,760

words

477

00:19:05,350 --> 00:19:02,000

so when we do this we'll find that

478

00:19:07,350 --> 00:19:05,360

astronomy is a system of rules laws or

479

00:19:09,190 --> 00:19:07,360

knowledge about star celestial bodies in

480

00:19:10,789 --> 00:19:09,200

outer space

481

00:19:13,029 --> 00:19:10,799

astrophysics

482

00:19:15,430 --> 00:19:13,039

tells us about the nature or natural

483

00:19:16,789 --> 00:19:15,440

order of star celestial bodies in outer

484

00:19:19,830 --> 00:19:16,799

space

485

00:19:22,310 --> 00:19:19,840

and finally astrology tells us about the

486

00:19:24,789 --> 00:19:22,320

field of study related to stars

487

00:19:26,630 --> 00:19:24,799

celestial bodies and outer space

488

00:19:28,789 --> 00:19:26,640

so i've kind of spoiled the punch line

489

00:19:30,390 --> 00:19:28,799

here a little bit with the title of this

490

00:19:31,669 --> 00:19:30,400

slide but it's clear from these

491

00:19:34,230 --> 00:19:31,679

definitions

492

00:19:36,950 --> 00:19:34,240

that etymology can't help us here right

493

00:19:38,470 --> 00:19:36,960

if we happen to be a contestant on the

494

00:19:40,070 --> 00:19:38,480

australian version of the bachelor in

495

00:19:42,710 --> 00:19:40,080

2019

496

00:19:45,190 --> 00:19:42,720

we would not be able to spout out these

497

00:19:46,789 --> 00:19:45,200

definitions and provide any meaningful

498

00:19:48,630 --> 00:19:46,799

information for the people who are

499

00:19:49,669 --> 00:19:48,640

confused about what an astrophysicist

500

00:19:51,590 --> 00:19:49,679

might do

501  
00:19:53,510 --> 00:19:51,600  
or about what the difference is between

502  
00:19:56,230 --> 00:19:53,520  
these three words

503  
00:19:58,150 --> 00:19:56,240  
so maybe it's not really fair to expect

504  
00:19:59,830 --> 00:19:58,160  
people to already know what the

505  
00:20:03,029 --> 00:19:59,840  
difference is between astronomy and

506  
00:20:05,830 --> 00:20:03,039  
astrophysics and astrology

507  
00:20:07,909 --> 00:20:05,840  
now we can learn a little bit more about

508  
00:20:10,149 --> 00:20:07,919  
why this confusion exists

509  
00:20:12,950 --> 00:20:10,159  
by taking another bit of a dive into

510  
00:20:18,470 --> 00:20:16,390  
so if we go to the wildly popular video

511  
00:20:19,830 --> 00:20:18,480  
sharing app tick tock

512  
00:20:21,830 --> 00:20:19,840  
we can do a quick little thought

513  
00:20:23,270 --> 00:20:21,840

experiment now i personally had to get

514

00:20:24,950 --> 00:20:23,280

rid of tick-tock off my phone at the

515

00:20:26,149 --> 00:20:24,960

beginning of the pandemic because all of

516

00:20:27,669 --> 00:20:26,159

a sudden it would be two o'clock in the

517

00:20:28,870 --> 00:20:27,679

morning and i'm still scrolling through

518

00:20:31,350 --> 00:20:28,880

videos

519

00:20:35,590 --> 00:20:31,360

but if any of you wanted to open up the

520

00:20:37,350 --> 00:20:35,600

app and search for a video on astrology

521

00:20:40,230 --> 00:20:37,360

you could search for videos that were

522

00:20:41,830 --> 00:20:40,240

tagged with this hashtag and that would

523

00:20:44,630 --> 00:20:41,840

tell you that the video mentioned

524

00:20:46,950 --> 00:20:44,640

something about astrology

525

00:20:49,590 --> 00:20:46,960

so when we do this we get a whole list

526  
00:20:51,990 --> 00:20:49,600  
of some of the more popular videos

527  
00:20:54,549 --> 00:20:52,000  
and we can see that all of the videos

528  
00:20:58,870 --> 00:20:54,559  
that are tagged as astrology

529  
00:21:00,950 --> 00:20:58,880  
have a total of 24.2 billion views

530  
00:21:04,470 --> 00:21:00,960  
now this is a lot this is a really big

531  
00:21:08,070 --> 00:21:04,480  
number and just for context there are

532  
00:21:09,510 --> 00:21:08,080  
just under 8 billion people in the world

533  
00:21:11,430 --> 00:21:09,520  
today

534  
00:21:14,470 --> 00:21:11,440  
so if these astrology videos have been

535  
00:21:17,270 --> 00:21:14,480  
viewed 24 billion times

536  
00:21:19,510 --> 00:21:17,280  
that means that's enough views for every

537  
00:21:22,310 --> 00:21:19,520  
single living person to have viewed

538  
00:21:23,990 --> 00:21:22,320

three videos on astrology

539

00:21:25,350 --> 00:21:24,000

and now of course we know that not every

540

00:21:27,029 --> 00:21:25,360

single person in the world is going to

541

00:21:28,549 --> 00:21:27,039

be on tick tock looking at astrology

542

00:21:30,549 --> 00:21:28,559

videos but this just gives us some

543

00:21:33,270 --> 00:21:30,559

context about how

544

00:21:36,310 --> 00:21:33,280

popular and widespread this information

545

00:21:38,310 --> 00:21:36,320

about astrology is

546

00:21:40,470 --> 00:21:38,320

now if we do the same thought experiment

547

00:21:42,710 --> 00:21:40,480

but instead of looking for videos tagged

548

00:21:44,149 --> 00:21:42,720

with astrology

549

00:21:46,230 --> 00:21:44,159

but look for videos tagged with

550

00:21:48,070 --> 00:21:46,240

astronomy or astrophysics

551  
00:21:51,110 --> 00:21:48,080  
we see that these videos have been

552  
00:21:53,029 --> 00:21:51,120  
viewed a combined total of only 540

553  
00:21:54,549 --> 00:21:53,039  
million times

554  
00:21:57,029 --> 00:21:54,559  
now this is still a pretty big number

555  
00:21:58,870 --> 00:21:57,039  
but it's certainly not 24 billion so

556  
00:22:01,990 --> 00:21:58,880  
just for context again

557  
00:22:04,710 --> 00:22:02,000  
a total of 540 million views would mean

558  
00:22:08,789 --> 00:22:04,720  
that there has been one video viewed for

559  
00:22:11,110 --> 00:22:08,799  
every 15 living people

560  
00:22:13,669 --> 00:22:11,120  
so this kind of gives us a sense that

561  
00:22:15,830 --> 00:22:13,679  
astrology is maybe a little bit more

562  
00:22:17,270 --> 00:22:15,840  
accessible to most people across the

563  
00:22:19,430 --> 00:22:17,280

globe and that astronomy and

564

00:22:20,470 --> 00:22:19,440

astrophysics may still be a little bit

565

00:22:22,149 --> 00:22:20,480

hidden

566

00:22:24,070 --> 00:22:22,159

and this is something that we as

567

00:22:25,750 --> 00:22:24,080

astronomers and astrophysicists at the

568

00:22:27,750 --> 00:22:25,760

space telescope science institute are

569

00:22:30,149 --> 00:22:27,760

actively thinking about is how we can

570

00:22:32,950 --> 00:22:30,159

make our work that we do here more

571

00:22:34,390 --> 00:22:32,960

accessible to everybody

572

00:22:35,990 --> 00:22:34,400

and it's something that maybe all of you

573

00:22:39,430 --> 00:22:36,000

after listening to this talk can think

574

00:22:42,390 --> 00:22:39,440

about doing moving forward as well

575

00:22:44,070 --> 00:22:42,400

so we've seen that maybe

576

00:22:46,230 --> 00:22:44,080

talking about the difference between

577

00:22:47,830 --> 00:22:46,240

astrology astronomy and astrophysics can

578

00:22:50,310 --> 00:22:47,840

get a little bit confusing right the

579

00:22:51,669 --> 00:22:50,320

words sound very similar

580

00:22:53,510 --> 00:22:51,679

so instead

581

00:22:54,950 --> 00:22:53,520

for the rest of the talk we'll reframe

582

00:22:57,669 --> 00:22:54,960

our question

583

00:22:59,270 --> 00:22:57,679

so instead we'll think about astronomers

584

00:23:01,190 --> 00:22:59,280

and astrophysicists

585

00:23:03,270 --> 00:23:01,200

versus astrologers

586

00:23:06,950 --> 00:23:03,280

and we'll try to answer the question of

587

00:23:09,430 --> 00:23:06,960

what they all do really

588

00:23:11,510 --> 00:23:09,440

so we'll proceed to answer this question

589

00:23:13,909 --> 00:23:11,520

with four steps

590

00:23:15,909 --> 00:23:13,919

we'll start by going through a brief

591

00:23:17,990 --> 00:23:15,919

history of human studying patterns in

592

00:23:19,750 --> 00:23:18,000

the night sky

593

00:23:21,909 --> 00:23:19,760

we'll talk about how then work

594

00:23:24,870 --> 00:23:21,919

transition to figuring out how celestial

595

00:23:26,710 --> 00:23:24,880

bodies move over time

596

00:23:29,270 --> 00:23:26,720

we'll talk about the divergence that we

597

00:23:31,350 --> 00:23:29,280

see in modern astronomy and astrophysics

598

00:23:32,870 --> 00:23:31,360

and astrology

599

00:23:34,950 --> 00:23:32,880

and finally i'll leave you with some

600

00:23:37,270 --> 00:23:34,960

more ways to explore the differences on

601  
00:23:39,909 --> 00:23:37,280  
your own that you can also feel free to

602  
00:23:41,510 --> 00:23:39,919  
share with other people as well

603  
00:23:44,230 --> 00:23:41,520  
but first we'll dive into our brief

604  
00:23:47,830 --> 00:23:46,950  
so for as long as humans have lived on

605  
00:23:50,230 --> 00:23:47,840  
earth

606  
00:23:52,390 --> 00:23:50,240  
we have archaeological records of people

607  
00:23:54,230 --> 00:23:52,400  
looking up at the sky and identifying

608  
00:23:58,230 --> 00:23:54,240  
patterns

609  
00:23:59,590 --> 00:23:58,240  
now this map of the world shows a red

610  
00:24:01,269 --> 00:23:59,600  
pin

611  
00:24:04,870 --> 00:24:01,279  
everywhere that we have really clear

612  
00:24:07,269 --> 00:24:04,880  
archaeological records of astronomical

613  
00:24:09,269 --> 00:24:07,279

observation so if people

614

00:24:11,190 --> 00:24:09,279

taking pictures or sorry drawing

615

00:24:13,830 --> 00:24:11,200

pictures and taking note

616

00:24:16,710 --> 00:24:13,840

of what they saw in the night sky

617

00:24:18,870 --> 00:24:16,720

and we can see that these

618

00:24:21,029 --> 00:24:18,880

this work really spanned the entire

619

00:24:24,070 --> 00:24:21,039

globe everyone who could possibly be

620

00:24:25,830 --> 00:24:24,080

looking up was doing so

621

00:24:26,710 --> 00:24:25,840

and we have some really neat evidence of

622

00:24:31,110 --> 00:24:26,720

this

623

00:24:33,909 --> 00:24:31,120

looking at a slab that is currently on

624

00:24:36,149 --> 00:24:33,919

display at the british museum

625

00:24:38,310 --> 00:24:36,159

and this slab was discovered in what is

626

00:24:41,029 --> 00:24:38,320

currently the middle east

627

00:24:43,830 --> 00:24:41,039

and it dates back to babylonian times so

628

00:24:46,470 --> 00:24:43,840

about 2 000 years ago

629

00:24:49,029 --> 00:24:46,480

and the markings on this slab

630

00:24:50,789 --> 00:24:49,039

are actually a lunar eclipse table

631

00:24:52,630 --> 00:24:50,799

so this tells us that people in

632

00:24:55,510 --> 00:24:52,640

babylonian times

633

00:24:57,269 --> 00:24:55,520

were monitoring the lunar eclipses and

634

00:25:00,230 --> 00:24:57,279

they were making predictions about when

635

00:25:02,950 --> 00:25:00,240

those eclipses would occur again and

636

00:25:05,590 --> 00:25:02,960

this type of record again is found all

637

00:25:09,350 --> 00:25:05,600

over the globe so the earliest eclipse

638

00:25:10,870 --> 00:25:09,360

records are date back to 4 000 to 4 500

639

00:25:14,950 --> 00:25:10,880

years ago people have been doing this

640

00:25:17,510 --> 00:25:14,960

for a really long time

641

00:25:19,029 --> 00:25:17,520

now in today's world of astronomy and

642

00:25:21,350 --> 00:25:19,039

astrophysics

643

00:25:24,230 --> 00:25:21,360

uh the international astronomical union

644

00:25:27,029 --> 00:25:24,240

recognizes a total of 88 constellations

645

00:25:29,430 --> 00:25:27,039

or 88 patterns in the sky and these are

646

00:25:30,789 --> 00:25:29,440

taken from greek and

647

00:25:33,350 --> 00:25:30,799

islamic

648

00:25:35,590 --> 00:25:33,360

astronomers

649

00:25:37,510 --> 00:25:35,600

now these 88 constellations that we

650

00:25:39,029 --> 00:25:37,520

recognize include the zodiac

651  
00:25:41,190 --> 00:25:39,039  
constellations

652  
00:25:43,590 --> 00:25:41,200  
so these you may recognize the names of

653  
00:25:45,110 --> 00:25:43,600  
some of these we have scorpius libra

654  
00:25:49,190 --> 00:25:45,120  
virgo leo

655  
00:25:52,070 --> 00:25:49,200  
cancer gemini taurus aries

656  
00:25:54,830 --> 00:25:52,080  
pisces aquarius capricornus and

657  
00:25:58,470 --> 00:25:54,840  
sagittarius

658  
00:26:01,669 --> 00:25:58,480  
now these zodiac constellations are very

659  
00:26:04,470 --> 00:26:01,679  
interesting because at the time that

660  
00:26:07,110 --> 00:26:04,480  
they were identified and mapped out

661  
00:26:09,029 --> 00:26:07,120  
people still thought that the sun

662  
00:26:10,789 --> 00:26:09,039  
actually traveled around the earth so

663  
00:26:11,830 --> 00:26:10,799

that the earth was the center of the

664

00:26:15,990 --> 00:26:11,840

universe

665

00:26:17,830 --> 00:26:16,000

and everything else uh orbited around it

666

00:26:19,510 --> 00:26:17,840

and so from our vantage point on this

667

00:26:22,149 --> 00:26:19,520

stationary earth

668

00:26:24,710 --> 00:26:22,159

it looks as though the sun is taking a

669

00:26:25,590 --> 00:26:24,720

path across the night sky now we know

670

00:26:29,830 --> 00:26:25,600

that

671

00:26:32,310 --> 00:26:29,840

rotating on its axis so we're either

672

00:26:34,310 --> 00:26:32,320

facing towards the sun or away from it

673

00:26:36,710 --> 00:26:34,320

but at the time it looked like the sun

674

00:26:39,830 --> 00:26:36,720

was traveling across the sky

675

00:26:42,549 --> 00:26:39,840

and it appeared to change position um

676  
00:26:45,830 --> 00:26:42,559  
every sunrise with uh respect to these

677  
00:26:47,909 --> 00:26:45,840  
background zodiac constellations

678  
00:26:49,590 --> 00:26:47,919  
and so this these zodiac constellations

679  
00:26:52,549 --> 00:26:49,600  
played a really important role and they

680  
00:26:53,669 --> 00:26:52,559  
acted as a good reference point

681  
00:26:55,590 --> 00:26:53,679  
now i want to point out that we're

682  
00:26:57,990 --> 00:26:55,600  
looking at the greek and arabic

683  
00:27:01,029 --> 00:26:58,000  
constellations

684  
00:27:03,669 --> 00:27:01,039  
and we'll focus on scorpius for now

685  
00:27:05,510 --> 00:27:03,679  
it turns out that not all civilizations

686  
00:27:08,070 --> 00:27:05,520  
across the globe that we're tracking

687  
00:27:10,070 --> 00:27:08,080  
these patterns of stars in the sky

688  
00:27:11,830 --> 00:27:10,080

interpreted the zodiac constellations in

689

00:27:14,789 --> 00:27:11,840

the same way

690

00:27:17,350 --> 00:27:14,799

now some did so for example astronomical

691

00:27:18,950 --> 00:27:17,360

records from the aztecs

692

00:27:23,909 --> 00:27:18,960

show that they also believe that

693

00:27:27,990 --> 00:27:26,149

but if we look at the constellations

694

00:27:29,590 --> 00:27:28,000

that were identified by chinese

695

00:27:31,029 --> 00:27:29,600

astronomers

696

00:27:33,110 --> 00:27:31,039

we can see that they had a much

697

00:27:35,669 --> 00:27:33,120

different interpretation

698

00:27:37,590 --> 00:27:35,679

so scorpius was actually two

699

00:27:39,750 --> 00:27:37,600

constellations that were part of a much

700

00:27:41,830 --> 00:27:39,760

larger pattern in the sky called the

701  
00:27:44,149 --> 00:27:41,840  
azure dragon

702  
00:27:47,430 --> 00:27:44,159  
and the constellation scorpius one part

703  
00:27:49,830 --> 00:27:47,440  
made up the tail of the azure dragon

704  
00:27:52,389 --> 00:27:49,840  
and the other part was described as a

705  
00:27:56,070 --> 00:27:52,399  
changing room or a temple within a

706  
00:27:57,510 --> 00:27:56,080  
mansion of the azure dragon

707  
00:27:59,990 --> 00:27:57,520  
so we can see and this is something

708  
00:28:01,269 --> 00:28:00,000  
that's important to remember is that the

709  
00:28:03,110 --> 00:28:01,279  
patterns

710  
00:28:05,029 --> 00:28:03,120  
in these stars were interpreted very

711  
00:28:07,430 --> 00:28:05,039  
differently across the globe despite the

712  
00:28:09,350 --> 00:28:07,440  
fact that now we recognize this one

713  
00:28:11,750 --> 00:28:09,360

fixed system so just something to keep

714

00:28:15,269 --> 00:28:13,430

but at the time

715

00:28:17,269 --> 00:28:15,279

astronomy and astrology were really the

716

00:28:19,430 --> 00:28:17,279

same thing

717

00:28:21,590 --> 00:28:19,440

and so people were able to use these

718

00:28:24,070 --> 00:28:21,600

zodiac constellations as well as lunar

719

00:28:27,909 --> 00:28:24,080

and solar eclipses as really useful

720

00:28:29,430 --> 00:28:27,919

references for the passage of time

721

00:28:31,190 --> 00:28:29,440

and astronomy

722

00:28:33,269 --> 00:28:31,200

astronomers and astrologers had a really

723

00:28:34,950 --> 00:28:33,279

important role at this time

724

00:28:36,630 --> 00:28:34,960

because it was their job to make

725

00:28:39,830 --> 00:28:36,640

predictions about lunar and solar

726

00:28:41,830 --> 00:28:39,840

eclipses and it was also their job to

727

00:28:43,830 --> 00:28:41,840

alert everyone to when for example the

728

00:28:44,710 --> 00:28:43,840

harvest season was coming or when there

729

00:28:46,149 --> 00:28:44,720

would be

730

00:28:47,750 --> 00:28:46,159

when we could expect to have more

731

00:28:50,710 --> 00:28:47,760

consistent warm weather and so in an

732

00:28:53,269 --> 00:28:50,720

agrarian society this was really really

733

00:28:56,070 --> 00:28:53,279

important information

734

00:28:58,070 --> 00:28:56,080

now of course there are stories of some

735

00:29:01,029 --> 00:28:58,080

ancient rulers using astrologers for

736

00:29:02,630 --> 00:29:01,039

more nefarious purposes so for example

737

00:29:04,389 --> 00:29:02,640

making predictions about when they

738

00:29:07,750 --> 00:29:04,399

should go to war

739

00:29:09,430 --> 00:29:07,760

um or when a ruler should be

740

00:29:12,149 --> 00:29:09,440

removed from the throne because they

741

00:29:13,909 --> 00:29:12,159

were abusing their power

742

00:29:14,950 --> 00:29:13,919

and it was very treacherous back then

743

00:29:16,470 --> 00:29:14,960

because people would kill their

744

00:29:18,789 --> 00:29:16,480

astrologers if they made predictions

745

00:29:20,549 --> 00:29:18,799

that were wrong or unfavorable

746

00:29:22,630 --> 00:29:20,559

but for many for

747

00:29:25,190 --> 00:29:22,640

a long long time this is what astronomy

748

00:29:27,669 --> 00:29:25,200

and astrology were

749

00:29:29,750 --> 00:29:27,679

and some of the seasons are still

750

00:29:32,710 --> 00:29:29,760

celebrated at different times across the

751  
00:29:35,510 --> 00:29:32,720  
globe so for example chinese new year is

752  
00:29:37,190 --> 00:29:35,520  
still celebrated uh in february at the

753  
00:29:40,630 --> 00:29:37,200  
beginning of february

754  
00:29:43,909 --> 00:29:40,640  
and so this marks the time uh two

755  
00:29:47,990 --> 00:29:43,919  
two lunar cycles after the 11th month of

756  
00:29:50,070 --> 00:29:48,000  
the year so it falls in early february

757  
00:29:52,149 --> 00:29:50,080  
my family is sri lankan and so in april

758  
00:29:55,190 --> 00:29:52,159  
we celebrate the tamil and sinhalese new

759  
00:29:58,310 --> 00:29:55,200  
years and so this marks the start of the

760  
00:29:59,909 --> 00:29:58,320  
harvest and planting season

761  
00:30:02,470 --> 00:29:59,919  
and it

762  
00:30:04,549 --> 00:30:02,480  
is celebrated on the first new moon

763  
00:30:06,549 --> 00:30:04,559

after the sun

764

00:30:08,470 --> 00:30:06,559

moves from rising in the constellation

765

00:30:09,830 --> 00:30:08,480

pisces to rising in the constellation

766

00:30:11,909 --> 00:30:09,840

aries

767

00:30:13,669 --> 00:30:11,919

and finally we're actually right in the

768

00:30:15,750 --> 00:30:13,679

middle of rosh hashanah or the jewish

769

00:30:17,830 --> 00:30:15,760

new year which is celebrated at the

770

00:30:18,950 --> 00:30:17,840

beginning of september

771

00:30:20,950 --> 00:30:18,960

and so

772

00:30:24,789 --> 00:30:20,960

our seasons and our celebrations are

773

00:30:26,149 --> 00:30:24,799

very much marked by the transition of

774

00:30:29,510 --> 00:30:26,159

sunrise through these different

775

00:30:33,190 --> 00:30:31,350

so this is our history right this is how

776

00:30:35,510 --> 00:30:33,200

humans first started to study these

777

00:30:37,430 --> 00:30:35,520

patterns in the sky

778

00:30:40,950 --> 00:30:37,440

but of course we always want to know

779

00:30:43,269 --> 00:30:40,960

more and the universe is always changing

780

00:30:45,750 --> 00:30:43,279

and doing something new and so new

781

00:30:47,590 --> 00:30:45,760

information started to come to light

782

00:30:53,269 --> 00:30:47,600

that helps people get a better sense of

783

00:30:58,630 --> 00:30:56,789

now heading into the 1500s

784

00:30:59,990 --> 00:30:58,640

copernicus

785

00:31:02,789 --> 00:31:00,000

started to

786

00:31:05,350 --> 00:31:02,799

work out the details of what we now call

787

00:31:07,909 --> 00:31:05,360

the heliocentric model

788

00:31:10,149 --> 00:31:07,919

so remember prior to this work people

789

00:31:11,669 --> 00:31:10,159

believed that the earth was the center

790

00:31:14,310 --> 00:31:11,679

of the universe

791

00:31:17,190 --> 00:31:14,320

and the sun orbited around the earth and

792

00:31:18,789 --> 00:31:17,200

everything else moved around the earth

793

00:31:21,269 --> 00:31:18,799

but copernicus

794

00:31:24,549 --> 00:31:21,279

and another philosopher long before him

795

00:31:27,190 --> 00:31:24,559

thought about this as well independently

796

00:31:28,950 --> 00:31:27,200

copernicus formulated our model that we

797

00:31:30,950 --> 00:31:28,960

now know to be correct

798

00:31:32,630 --> 00:31:30,960

where we have the sun at the center of

799

00:31:34,630 --> 00:31:32,640

the solar system

800

00:31:36,630 --> 00:31:34,640

and the earth and all the other planets

801  
00:31:38,950 --> 00:31:36,640  
orbit around it

802  
00:31:40,710 --> 00:31:38,960  
now this was controversial at the time

803  
00:31:43,509 --> 00:31:40,720  
because it went against the grain of

804  
00:31:45,830 --> 00:31:43,519  
what people had believed for a very long

805  
00:31:48,470 --> 00:31:45,840  
time and so copernicus was naturally

806  
00:31:50,870 --> 00:31:48,480  
very hesitant to publish

807  
00:31:52,630 --> 00:31:50,880  
but he received a letter from the

808  
00:31:54,710 --> 00:31:52,640  
cardinal of kapua and i'm showing a

809  
00:31:56,149 --> 00:31:54,720  
translated clip here we'll read through

810  
00:31:58,389 --> 00:31:56,159  
it

811  
00:31:59,269 --> 00:31:58,399  
and the cardinal wrote to copernicus and

812  
00:32:01,430 --> 00:31:59,279  
said

813  
00:32:03,430 --> 00:32:01,440

some years ago word reached me

814

00:32:06,310 --> 00:32:03,440

concerning your proficiency

815

00:32:08,870 --> 00:32:06,320

of which everybody constantly spoke

816

00:32:10,230 --> 00:32:08,880

at that time i began to have a very high

817

00:32:11,830 --> 00:32:10,240

regard for you

818

00:32:13,750 --> 00:32:11,840

and also to congratulate our

819

00:32:15,590 --> 00:32:13,760

contemporaries among whom you enjoyed

820

00:32:17,269 --> 00:32:15,600

such great prestige

821

00:32:19,029 --> 00:32:17,279

for i had learned that you had not

822

00:32:21,750 --> 00:32:19,039

merely mastered the discoveries of the

823

00:32:25,430 --> 00:32:21,760

ancient astronomers uncommonly well

824

00:32:28,389 --> 00:32:25,440

but had also formulated a new cosmology

825

00:32:30,549 --> 00:32:28,399

in it you maintain that the earth moves

826

00:32:33,350 --> 00:32:30,559

that the sun occupies the lowest and

827

00:32:34,870 --> 00:32:33,360

thus the central place in the universe

828

00:32:37,430 --> 00:32:34,880

that the eighth heaven remain

829

00:32:39,029 --> 00:32:37,440

perpetually motionless and fixed

830

00:32:41,990 --> 00:32:39,039

and that together with the elements

831

00:32:44,470 --> 00:32:42,000

included in its sphere the moon situated

832

00:32:46,789 --> 00:32:44,480

between the heavens of mars and venus

833

00:32:48,470 --> 00:32:46,799

revolves around the sun in the period of

834

00:32:50,230 --> 00:32:48,480

a year

835

00:32:52,950 --> 00:32:50,240

and he goes on to give copernicus a

836

00:32:55,350 --> 00:32:52,960

little bit more flattering and concludes

837

00:32:57,990 --> 00:32:55,360

uh by saying therefore

838

00:33:00,149 --> 00:32:58,000

with the utmost earnestness i entreat

839

00:33:01,669 --> 00:33:00,159

you most learned sir unless i

840

00:33:03,750 --> 00:33:01,679

inconvenience you

841

00:33:06,230 --> 00:33:03,760

to communicate this discovery of yours

842

00:33:07,990 --> 00:33:06,240

to scholars and at the earliest possible

843

00:33:10,310 --> 00:33:08,000

moment to send me your writings on the

844

00:33:12,070 --> 00:33:10,320

sphere of the universe together with

845

00:33:15,669 --> 00:33:12,080

whatever tables and whatever else you

846

00:33:17,590 --> 00:33:15,679

have that is relevant to this subject

847

00:33:20,710 --> 00:33:17,600

and so people were very interested there

848

00:33:23,350 --> 00:33:20,720

was a lot of interest in this idea of a

849

00:33:25,110 --> 00:33:23,360

heliocentric model of the universe and

850

00:33:27,190 --> 00:33:25,120

we now know that you know the sun is not

851  
00:33:28,950 --> 00:33:27,200  
the center of the universe but this was

852  
00:33:30,870 --> 00:33:28,960  
really revolutionary thinking at the

853  
00:33:33,190 --> 00:33:30,880  
time that people were excited about and

854  
00:33:35,350 --> 00:33:33,200  
so the wheels were starting to turn

855  
00:33:37,190 --> 00:33:35,360  
that maybe the patterns of motion seen

856  
00:33:42,789 --> 00:33:37,200  
in the night sky were not quite what

857  
00:33:49,350 --> 00:33:46,389  
then we come to the year 1572

858  
00:33:51,909 --> 00:33:49,360  
and the astronomer and astrologer tycho

859  
00:33:54,230 --> 00:33:51,919  
brahe identifies something very

860  
00:33:55,909 --> 00:33:54,240  
interesting in the sky

861  
00:33:57,750 --> 00:33:55,919  
so he was looking at the constellation

862  
00:34:01,029 --> 00:33:57,760  
cassiopeia

863  
00:34:04,230 --> 00:34:01,039

and noticed in 1572 that all of a sudden

864

00:34:06,789 --> 00:34:04,240

a very bright new star or nova

865

00:34:08,869 --> 00:34:06,799

appeared in the sky

866

00:34:10,950 --> 00:34:08,879

now we're looking at this we now know

867

00:34:13,190 --> 00:34:10,960

that this was a supernova

868

00:34:14,389 --> 00:34:13,200

and when we point our x-ray telescopes

869

00:34:17,270 --> 00:34:14,399

at it we see

870

00:34:19,909 --> 00:34:17,280

these this beautiful remnant gas and

871

00:34:22,149 --> 00:34:19,919

this is very hot ionized material that

872

00:34:24,389 --> 00:34:22,159

produces x-rays that we can collect at

873

00:34:26,230 --> 00:34:24,399

our telescopes here

874

00:34:28,310 --> 00:34:26,240

but at the time you know tycho brahe

875

00:34:31,829 --> 00:34:28,320

did not have an x-ray telescope

876

00:34:34,069 --> 00:34:31,839

and so he just saw this bright spot

877

00:34:35,430 --> 00:34:34,079

now this was really remarkable because

878

00:34:37,109 --> 00:34:35,440

the bright spot

879

00:34:40,389 --> 00:34:37,119

was actually more comparable in

880

00:34:43,270 --> 00:34:40,399

brightness to the planets than it was to

881

00:34:45,190 --> 00:34:43,280

the background stars

882

00:34:46,790 --> 00:34:45,200

and we saw that the cardinal mentioned

883

00:34:48,710 --> 00:34:46,800

something called the eighth heaven in

884

00:34:50,710 --> 00:34:48,720

his letter to kepler

885

00:34:53,109 --> 00:34:50,720

that was the term that was used at the

886

00:34:55,829 --> 00:34:53,119

time for the background stars that were

887

00:34:58,069 --> 00:34:55,839

much fainter than this new star that had

888

00:34:59,109 --> 00:34:58,079

appeared

889

00:35:01,670 --> 00:34:59,119

and so

890

00:35:03,190 --> 00:35:01,680

the appearance of this bright star was

891

00:35:05,510 --> 00:35:03,200

very interesting

892

00:35:07,750 --> 00:35:05,520

because up until this point people had

893

00:35:10,950 --> 00:35:07,760

thought that the eighth heaven or those

894

00:35:13,990 --> 00:35:10,960

fixed background stars didn't change

895

00:35:15,030 --> 00:35:14,000

that they just remained constant

896

00:35:17,589 --> 00:35:15,040

and

897

00:35:19,910 --> 00:35:17,599

nothing new would ever happen

898

00:35:22,950 --> 00:35:19,920

and so the appearance of this bright new

899

00:35:24,550 --> 00:35:22,960

star was really something remarkable

900

00:35:26,470 --> 00:35:24,560

um and other people were able to notice

901  
00:35:28,950 --> 00:35:26,480  
it too but taekworah he was really known

902  
00:35:31,829 --> 00:35:28,960  
for being a very careful recorder of

903  
00:35:33,430 --> 00:35:31,839  
observations and so

904  
00:35:38,069 --> 00:35:33,440  
he was really the one who kind of

905  
00:35:38,950 --> 00:35:38,079  
pioneered the work on this new nova

906  
00:35:42,069 --> 00:35:38,960  
now

907  
00:35:43,829 --> 00:35:42,079  
about 30 years later

908  
00:35:45,829 --> 00:35:43,839  
another new star appeared in the night

909  
00:35:48,150 --> 00:35:45,839  
sky and this time

910  
00:35:49,990 --> 00:35:48,160  
kepler was the person to monitor it very

911  
00:35:51,589 --> 00:35:50,000  
carefully now kepler is not necessarily

912  
00:35:53,270 --> 00:35:51,599  
the person who first discovered this

913  
00:35:55,510 --> 00:35:53,280

bright new star

914

00:35:56,630 --> 00:35:55,520

a lot of other people had seen it as

915

00:35:58,710 --> 00:35:56,640

well

916

00:36:01,829 --> 00:35:58,720

but kepler played a very important role

917

00:36:04,550 --> 00:36:01,839

here because at the time in 1604

918

00:36:06,550 --> 00:36:04,560

he was working as a mathematician and

919

00:36:08,870 --> 00:36:06,560

astronomer and astrologer

920

00:36:10,870 --> 00:36:08,880

in service to the emperor

921

00:36:13,030 --> 00:36:10,880

and so it was really important for him

922

00:36:14,710 --> 00:36:13,040

to provide some interpretation of what

923

00:36:17,910 --> 00:36:14,720

was happening in the skies right this

924

00:36:20,069 --> 00:36:17,920

was his job he was very important

925

00:36:21,910 --> 00:36:20,079

and here of course we are looking at a

926  
00:36:24,150 --> 00:36:21,920  
beautiful hubble image

927  
00:36:26,390 --> 00:36:24,160  
of what is colloquially known as kepler

928  
00:36:28,550 --> 00:36:26,400  
supernova this was actually

929  
00:36:32,150 --> 00:36:28,560  
put together by taken and put together

930  
00:36:33,829 --> 00:36:32,160  
by scientists here at space telescope

931  
00:36:36,630 --> 00:36:33,839  
but at the time again this just looked

932  
00:36:37,430 --> 00:36:36,640  
like a bright star

933  
00:36:39,510 --> 00:36:37,440  
now

934  
00:36:42,470 --> 00:36:39,520  
the appearance of this new star happened

935  
00:36:43,829 --> 00:36:42,480  
to come at a very interesting time

936  
00:36:46,310 --> 00:36:43,839  
uh because

937  
00:36:49,670 --> 00:36:46,320  
at the time astronomers and astrologers

938  
00:36:51,589 --> 00:36:49,680

were noticing that the planets jupiter

939

00:36:54,230 --> 00:36:51,599

saturn and mars

940

00:36:58,550 --> 00:36:54,240

appeared very close together in the sky

941

00:37:00,310 --> 00:36:58,560

and so this was known as a conjunction

942

00:37:02,870 --> 00:37:00,320

and so kepler's interpretation which

943

00:37:05,670 --> 00:37:02,880

again has been translated here

944

00:37:07,750 --> 00:37:05,680

was that the star significance is a

945

00:37:10,470 --> 00:37:07,760

difficult matter to establish

946

00:37:12,790 --> 00:37:10,480

and we can be sure of only one thing

947

00:37:14,790 --> 00:37:12,800

that either the star signifies nothing

948

00:37:17,190 --> 00:37:14,800

at all for mankind

949

00:37:19,750 --> 00:37:17,200

or it signifies something of such

950

00:37:22,950 --> 00:37:19,760

exalted importance that it is beyond the

951  
00:37:25,270 --> 00:37:22,960  
grasp and understanding of any man

952  
00:37:28,230 --> 00:37:25,280  
this star is so far above all the

953  
00:37:30,390 --> 00:37:28,240  
planets that from its position according

954  
00:37:32,550 --> 00:37:30,400  
to the teaching of copernicus

955  
00:37:33,829 --> 00:37:32,560  
not only would the bodies of the planets

956  
00:37:36,069 --> 00:37:33,839  
be invisible

957  
00:37:38,069 --> 00:37:36,079  
but even their whole orbital spheres

958  
00:37:39,430 --> 00:37:38,079  
would appear as small as very faint

959  
00:37:41,589 --> 00:37:39,440  
stars

960  
00:37:43,670 --> 00:37:41,599  
therefore from all the astrologers can

961  
00:37:45,670 --> 00:37:43,680  
tell us and from all we know about the

962  
00:37:48,630 --> 00:37:45,680  
great conjunction of saturn jupiter and

963  
00:37:51,190 --> 00:37:48,640

mars we can deduce nothing at all about

964

00:37:53,349 --> 00:37:51,200

the flaring up of the star or about its

965

00:37:55,829 --> 00:37:53,359

substance

966

00:37:57,190 --> 00:37:55,839

now this is a little bit of a confusing

967

00:37:59,270 --> 00:37:57,200

interpretation so we're going to break

968

00:38:01,030 --> 00:37:59,280

it down a little bit

969

00:38:03,270 --> 00:38:01,040

now because

970

00:38:05,430 --> 00:38:03,280

this new star was so bright again it was

971

00:38:07,670 --> 00:38:05,440

closer in brightness to the planets than

972

00:38:09,910 --> 00:38:07,680

the background stars

973

00:38:11,430 --> 00:38:09,920

uh astrologers at the time were

974

00:38:14,550 --> 00:38:11,440

interpreting it as something that had

975

00:38:16,550 --> 00:38:14,560

been manifested by the planets

976

00:38:19,109 --> 00:38:16,560

but kepler was very clever

977

00:38:21,190 --> 00:38:19,119

when he was looking at the motions of

978

00:38:24,150 --> 00:38:21,200

things in the sky through the night

979

00:38:26,470 --> 00:38:24,160

he noticed that this new star

980

00:38:28,790 --> 00:38:26,480

actually didn't move

981

00:38:31,349 --> 00:38:28,800

and so he realized that if it were

982

00:38:33,910 --> 00:38:31,359

really associated with the planets

983

00:38:36,950 --> 00:38:33,920

it would maybe move faster through the

984

00:38:38,870 --> 00:38:36,960

night sky at the same speed that we see

985

00:38:40,470 --> 00:38:38,880

the planets and the moon moving over

986

00:38:42,150 --> 00:38:40,480

time

987

00:38:43,109 --> 00:38:42,160

and so he

988

00:38:45,349 --> 00:38:43,119

thought

989

00:38:47,349 --> 00:38:45,359

that this bright new star was probably

990

00:38:49,510 --> 00:38:47,359

further away

991

00:38:51,430 --> 00:38:49,520

than the planets and the moon which is

992

00:38:53,510 --> 00:38:51,440

why he says here you know not only would

993

00:38:55,190 --> 00:38:53,520

the bodies of the planets be invisible

994

00:38:56,950 --> 00:38:55,200

but even their whole orbital spheres

995

00:38:59,430 --> 00:38:56,960

would appear as small as very faint

996

00:39:01,990 --> 00:38:59,440

stars so he built on the work of

997

00:39:03,990 --> 00:39:02,000

copernicus and was able to do a little

998

00:39:07,030 --> 00:39:04,000

bit of interpretation of this new star

999

00:39:07,829 --> 00:39:07,040

in that heliocentric framework

1000

00:39:10,150 --> 00:39:07,839

okay

1001  
00:39:12,069 --> 00:39:10,160  
so the pieces are very slowly starting

1002  
00:39:14,550 --> 00:39:12,079  
to come together people are starting to

1003  
00:39:17,270 --> 00:39:14,560  
learn some new things about how objects

1004  
00:39:20,710 --> 00:39:17,280  
move through the sky

1005  
00:39:23,030 --> 00:39:20,720  
and then in 1610 galileo made a very

1006  
00:39:25,190 --> 00:39:23,040  
interesting discovery

1007  
00:39:26,470 --> 00:39:25,200  
so galileo pointed his telescope at

1008  
00:39:28,310 --> 00:39:26,480  
jupiter

1009  
00:39:31,510 --> 00:39:28,320  
and this picture that we're looking at

1010  
00:39:33,510 --> 00:39:31,520  
here is actually taken from his

1011  
00:39:35,270 --> 00:39:33,520  
uh observations log from the night that

1012  
00:39:37,670 --> 00:39:35,280  
he was looking at jupiter

1013  
00:39:39,910 --> 00:39:37,680

so he made a lot of drawings and he drew

1014

00:39:42,630 --> 00:39:39,920

jupiter at this pinwheel thing that is

1015

00:39:44,790 --> 00:39:42,640

this pinwheel thing that we see here

1016

00:39:47,910 --> 00:39:44,800

and when he first looked at jupiter he

1017

00:39:51,190 --> 00:39:47,920

also noticed three much fainter points

1018

00:39:53,030 --> 00:39:51,200

of light that were all in a row

1019

00:39:55,030 --> 00:39:53,040

and he noticed that as he monitored

1020

00:39:57,829 --> 00:39:55,040

these this system over the course of the

1021

00:40:00,310 --> 00:39:57,839

night the three fainter dots changed

1022

00:40:02,390 --> 00:40:00,320

position so for example here they were

1023

00:40:04,230 --> 00:40:02,400

all three in a row on once on the right

1024

00:40:06,230 --> 00:40:04,240

hand side of the planet

1025

00:40:07,990 --> 00:40:06,240

then later there were two on one side of

1026  
00:40:10,790 --> 00:40:08,000  
the planet and a third on the right hand

1027  
00:40:12,790 --> 00:40:10,800  
side and so on and eventually a fourth

1028  
00:40:15,349 --> 00:40:12,800  
dot appeared

1029  
00:40:17,829 --> 00:40:15,359  
so we now know that these are the four

1030  
00:40:19,430 --> 00:40:17,839  
biggest moons of jupiter that galileo

1031  
00:40:21,829 --> 00:40:19,440  
had discovered which is why we call them

1032  
00:40:23,829 --> 00:40:21,839  
the galilean moons

1033  
00:40:25,270 --> 00:40:23,839  
and this was extremely exciting first of

1034  
00:40:28,150 --> 00:40:25,280  
all it's always very exciting to

1035  
00:40:30,710 --> 00:40:28,160  
discover moons that's a big deal

1036  
00:40:31,750 --> 00:40:30,720  
but it also really provided conclusive

1037  
00:40:34,230 --> 00:40:31,760  
evidence

1038  
00:40:36,630 --> 00:40:34,240

that objects could orbit

1039

00:40:39,190 --> 00:40:36,640

other things that were not the earth

1040

00:40:40,710 --> 00:40:39,200

so if the moons could orbit jupiter then

1041

00:40:43,109 --> 00:40:40,720

maybe everything didn't have to go

1042

00:40:47,190 --> 00:40:43,119

around the earth and this provided some

1043

00:40:49,030 --> 00:40:47,200

further support for copernicus's idea of

1044

00:40:50,950 --> 00:40:49,040

a heliocentric

1045

00:40:53,670 --> 00:40:50,960

universe

1046

00:40:55,190 --> 00:40:53,680

now jupiter's moons are still something

1047

00:40:57,109 --> 00:40:55,200

that are one of my favorite things to

1048

00:40:58,630 --> 00:40:57,119

observe in the night sky and actually

1049

00:40:59,910 --> 00:40:58,640

there's a very dorky photo of me

1050

00:41:03,030 --> 00:40:59,920

floating around somewhere on the

1051  
00:41:04,790 --> 00:41:03,040  
internet um looking at this manuscript

1052  
00:41:07,030 --> 00:41:04,800  
because it's on display in the library

1053  
00:41:08,630 --> 00:41:07,040  
at the university of michigan

1054  
00:41:10,309 --> 00:41:08,640  
but when observing knights are able to

1055  
00:41:12,470 --> 00:41:10,319  
start up again

1056  
00:41:14,870 --> 00:41:12,480  
you can look at jupiter

1057  
00:41:16,390 --> 00:41:14,880  
and you can see the dots for yourself

1058  
00:41:18,550 --> 00:41:16,400  
and if you come back you know maybe an

1059  
00:41:20,630 --> 00:41:18,560  
hour or two hours later you can see how

1060  
00:41:22,790 --> 00:41:20,640  
the dots change and so you can you know

1061  
00:41:24,390 --> 00:41:22,800  
pretend to be galileo and make some of

1062  
00:41:25,670 --> 00:41:24,400  
these observations yourself it's great

1063  
00:41:27,430 --> 00:41:25,680

fun

1064

00:41:28,950 --> 00:41:27,440

okay so the wheels are turning and

1065

00:41:31,829 --> 00:41:28,960

people are starting to realize that

1066

00:41:33,750 --> 00:41:31,839

maybe this idea of copernicus's has some

1067

00:41:36,390 --> 00:41:33,760

merit

1068

00:41:39,349 --> 00:41:36,400

and then finally newton came along

1069

00:41:40,790 --> 00:41:39,359

um and presented his law of universal

1070

00:41:42,870 --> 00:41:40,800

gravitation

1071

00:41:45,829 --> 00:41:42,880

that stated that everything in the

1072

00:41:49,030 --> 00:41:45,839

universe was gravitationally bound

1073

00:41:51,750 --> 00:41:49,040

and so this meant that the planets were

1074

00:41:53,670 --> 00:41:51,760

gravitationally bound to the sun

1075

00:41:55,349 --> 00:41:53,680

jupiter's moons were gravitationally

1076

00:41:57,510 --> 00:41:55,359

bound to jupiter

1077

00:41:59,750 --> 00:41:57,520

and this is what caused the planets to

1078

00:42:01,910 --> 00:41:59,760

travel around the sun

1079

00:42:03,510 --> 00:42:01,920

and this was this fit very nicely with

1080

00:42:06,150 --> 00:42:03,520

kepler's laws

1081

00:42:08,710 --> 00:42:06,160

because kepler had also discovered that

1082

00:42:10,630 --> 00:42:08,720

the planets much closer to the sun

1083

00:42:12,630 --> 00:42:10,640

would take less time to go all the way

1084

00:42:14,309 --> 00:42:12,640

around it while the planets further away

1085

00:42:15,910 --> 00:42:14,319

would take more time

1086

00:42:18,230 --> 00:42:15,920

so the puzzle pieces really came

1087

00:42:21,030 --> 00:42:18,240

together and this is really where it

1088

00:42:24,230 --> 00:42:21,040

became clear that astronomy and physics

1089

00:42:26,309 --> 00:42:24,240

are very intricately linked

1090

00:42:28,710 --> 00:42:26,319

and so from this point the field started

1091

00:42:31,349 --> 00:42:28,720

to branch off um astrology started to

1092

00:42:33,349 --> 00:42:31,359

fall out of favor and astronomy and

1093

00:42:36,630 --> 00:42:33,359

physics were pursued more closely

1094

00:42:40,309 --> 00:42:38,309

now i told you that we were going to

1095

00:42:42,230 --> 00:42:40,319

talk about the diverseness in modern

1096

00:42:44,230 --> 00:42:42,240

astronomy and astrophysics and astrology

1097

00:42:45,510 --> 00:42:44,240

because we're seeing that astrology

1098

00:42:48,470 --> 00:42:45,520

still

1099

00:42:50,550 --> 00:42:48,480

is something that appears in our modern

1100

00:42:51,829 --> 00:42:50,560

lives today

1101

00:42:53,510 --> 00:42:51,839

and you'll also

1102

00:42:55,190 --> 00:42:53,520

notice that when we come back to our

1103

00:42:58,309 --> 00:42:55,200

original question

1104

00:43:00,390 --> 00:42:58,319

i asked this in present tense so

1105

00:43:03,589 --> 00:43:00,400

astronomers and astrophysicists versus

1106

00:43:06,470 --> 00:43:03,599

astrologers what do they all do really

1107

00:43:08,150 --> 00:43:06,480

not what did they all do

1108

00:43:10,069 --> 00:43:08,160

now we can answer this question by

1109

00:43:11,030 --> 00:43:10,079

thinking about some recent celestial

1110

00:43:13,589 --> 00:43:11,040

events

1111

00:43:16,630 --> 00:43:13,599

and so for example we can pretend that

1112

00:43:18,790 --> 00:43:16,640

we're kepler but many many years later

1113

00:43:21,670 --> 00:43:18,800

and we can think about the great

1114

00:43:23,829 --> 00:43:21,680

conjunction of jupiter and saturn

1115

00:43:24,829 --> 00:43:23,839

now this was something that happened in

1116

00:43:27,430 --> 00:43:24,839

december

1117

00:43:29,750 --> 00:43:27,440

2020 and this picture was taken from

1118

00:43:31,670 --> 00:43:29,760

just down the road from us in baltimore

1119

00:43:33,750 --> 00:43:31,680

in murray virginia

1120

00:43:36,309 --> 00:43:33,760

and we can see this really bright spot

1121

00:43:38,790 --> 00:43:36,319

in the image this is the planet jupiter

1122

00:43:42,309 --> 00:43:38,800

and the fainter spot is the planet

1123

00:43:44,470 --> 00:43:42,319

saturn the planet saturn

1124

00:43:47,589 --> 00:43:44,480

now the great conjunction happened when

1125

00:43:49,510 --> 00:43:47,599

it looked like jupiter and saturn were

1126

00:43:51,109 --> 00:43:49,520

meeting in the sky

1127

00:43:52,870 --> 00:43:51,119

uh and everybody was really excited

1128

00:43:54,069 --> 00:43:52,880

about it i know all of my neighbors were

1129

00:43:55,430 --> 00:43:54,079

out and about trying to figure out how

1130

00:43:57,750 --> 00:43:55,440

to watch it

1131

00:43:59,430 --> 00:43:57,760

unfortunately here in baltimore it was

1132

00:44:01,030 --> 00:43:59,440

really cloudy and rainy

1133

00:44:02,390 --> 00:44:01,040

at the time of the conjunction so i

1134

00:44:03,910 --> 00:44:02,400

didn't get to see it in person but it

1135

00:44:05,829 --> 00:44:03,920

was really cool to see everybody's

1136

00:44:08,230 --> 00:44:05,839

pictures

1137

00:44:10,230 --> 00:44:08,240

now in the in the weeks and months

1138

00:44:12,230 --> 00:44:10,240

leading up to the conjunction

1139

00:44:13,670 --> 00:44:12,240

there were astrology headlines

1140

00:44:15,829 --> 00:44:13,680

everywhere

1141

00:44:18,069 --> 00:44:15,839

and the astrologers were assigning

1142

00:44:20,470 --> 00:44:18,079

importance to the conjunction itself and

1143

00:44:22,150 --> 00:44:20,480

using it to predict human behavior

1144

00:44:24,230 --> 00:44:22,160

so for example there were headlines

1145

00:44:25,910 --> 00:44:24,240

declaring that the biggest astrological

1146

00:44:27,670 --> 00:44:25,920

event of our lifetime would arrive on

1147

00:44:29,510 --> 00:44:27,680

december 21st

1148

00:44:31,910 --> 00:44:29,520

and people were offering predictions

1149

00:44:35,270 --> 00:44:31,920

about how this might impact somebody's

1150

00:44:36,710 --> 00:44:35,280

career or love life or more

1151  
00:44:38,630 --> 00:44:36,720  
people were asking whether this was the

1152  
00:44:40,710 --> 00:44:38,640  
age of aquarius and trying to understand

1153  
00:44:42,230 --> 00:44:40,720  
what it meant that the conjunction had

1154  
00:44:43,910 --> 00:44:42,240  
shown up

1155  
00:44:45,829 --> 00:44:43,920  
uh and people were also making

1156  
00:44:48,470 --> 00:44:45,839  
predictions about more large-scale

1157  
00:44:50,950 --> 00:44:48,480  
things that might happen in society um

1158  
00:44:52,870 --> 00:44:50,960  
so for example this german astrologer

1159  
00:44:54,790 --> 00:44:52,880  
randy rosenbaum said

1160  
00:44:56,470 --> 00:44:54,800  
people are saying that this is the same

1161  
00:44:57,510 --> 00:44:56,480  
alignment that happened when jesus was

1162  
00:44:59,430 --> 00:44:57,520  
born

1163  
00:45:00,790 --> 00:44:59,440

i have been hoping for a second coming

1164

00:45:03,109 --> 00:45:00,800

of christ to polish off the end of the

1165

00:45:05,030 --> 00:45:03,119

year but living in the 21st century i

1166

00:45:07,270 --> 00:45:05,040

speculate this can look like an alien

1167

00:45:08,790 --> 00:45:07,280

invasion it's always been omen in

1168

00:45:11,270 --> 00:45:08,800

astrology

1169

00:45:13,750 --> 00:45:11,280

and so we can see that these predictions

1170

00:45:15,190 --> 00:45:13,760

varied pretty wildly so the astrologers

1171

00:45:18,710 --> 00:45:15,200

were

1172

00:45:20,470 --> 00:45:18,720

knew that the conjunction was coming

1173

00:45:22,230 --> 00:45:20,480

and then used it to make some

1174

00:45:24,470 --> 00:45:22,240

predictions about what what might happen

1175

00:45:26,710 --> 00:45:24,480

to individual people and society as a

1176

00:45:28,950 --> 00:45:26,720

whole

1177

00:45:31,030 --> 00:45:28,960

now astronomers and astrophysicists like

1178

00:45:33,510 --> 00:45:31,040

myself and like my colleagues at the

1179

00:45:35,910 --> 00:45:33,520

space telescope science institute

1180

00:45:37,190 --> 00:45:35,920

don't assign meaning to the conjunction

1181

00:45:40,470 --> 00:45:37,200

itself

1182

00:45:43,030 --> 00:45:40,480

um instead you know we know from the

1183

00:45:46,069 --> 00:45:43,040

from the work of kepler and newton

1184

00:45:49,750 --> 00:45:46,079

that this alignment happens because the

1185

00:45:51,349 --> 00:45:49,760

orbital paths of jupiter and saturn

1186

00:45:52,870 --> 00:45:51,359

make it so that it looks like the

1187

00:45:53,750 --> 00:45:52,880

planets are passing in front of each

1188

00:45:56,309 --> 00:45:53,760

other

1189

00:45:58,470 --> 00:45:56,319

when in reality saturn is much farther

1190

00:46:01,510 --> 00:45:58,480

away than jupiter and so it's just it's

1191

00:46:03,270 --> 00:46:01,520

an optical effect that it appears like

1192

00:46:05,030 --> 00:46:03,280

the two planets are meeting in the night

1193

00:46:07,270 --> 00:46:05,040

sky

1194

00:46:08,710 --> 00:46:07,280

uh but we're still very interested in

1195

00:46:10,790 --> 00:46:08,720

jupiter and saturn they're really

1196

00:46:12,550 --> 00:46:10,800

interesting giant planets

1197

00:46:14,550 --> 00:46:12,560

and we're also very interested in

1198

00:46:16,309 --> 00:46:14,560

looking at their moons

1199

00:46:18,870 --> 00:46:16,319

so for example this is a really

1200

00:46:21,109 --> 00:46:18,880

beautiful image that was taken this july

1201  
00:46:23,670 --> 00:46:21,119  
by the juno spacecraft

1202  
00:46:25,589 --> 00:46:23,680  
and this is a picture of jupiter's moon

1203  
00:46:27,750 --> 00:46:25,599  
ganymede so this is one of the galilean

1204  
00:46:29,190 --> 00:46:27,760  
moons that galileo first noticed in his

1205  
00:46:31,670 --> 00:46:29,200  
telescope

1206  
00:46:33,750 --> 00:46:31,680  
now uh this picture is much more

1207  
00:46:34,870 --> 00:46:33,760  
detailed than what galileo was able to

1208  
00:46:37,349 --> 00:46:34,880  
draw

1209  
00:46:39,109 --> 00:46:37,359  
and this is because it was taken by the

1210  
00:46:42,309 --> 00:46:39,119  
juno spacecraft

1211  
00:46:45,030 --> 00:46:42,319  
now juno was launched in 2011 and took

1212  
00:46:47,670 --> 00:46:45,040  
five years to get to jupiter

1213  
00:46:48,630 --> 00:46:47,680

uh and it took this picture again in

1214

00:46:50,790 --> 00:46:48,640

july

1215

00:46:53,349 --> 00:46:50,800

in infrared light and so we're

1216

00:46:56,230 --> 00:46:53,359

essentially seeing the the heat that's

1217

00:46:58,309 --> 00:46:56,240

coming off of this icy moon

1218

00:47:00,790 --> 00:46:58,319

and astronomers and planetary scientists

1219

00:47:01,750 --> 00:47:00,800

will be studying the surface of this icy

1220

00:47:03,750 --> 00:47:01,760

moon

1221

00:47:07,430 --> 00:47:03,760

and looking for to see if they can

1222

00:47:09,030 --> 00:47:07,440

understand how high energy particles

1223

00:47:11,670 --> 00:47:09,040

impact both the structure and the

1224

00:47:13,349 --> 00:47:11,680

composition of ice on the moon

1225

00:47:16,150 --> 00:47:13,359

so this is really interesting neat

1226  
00:47:21,430 --> 00:47:18,309  
now astronomers and astrophysicists are

1227  
00:47:23,910 --> 00:47:21,440  
interested in saturn's moon as well

1228  
00:47:27,109 --> 00:47:23,920  
and this image on the right here is an

1229  
00:47:28,870 --> 00:47:27,119  
artist's depiction of dragonfly

1230  
00:47:32,150 --> 00:47:28,880  
a dragonfly is a mission that was

1231  
00:47:34,630 --> 00:47:32,160  
selected to go to saturn's moon titan

1232  
00:47:36,790 --> 00:47:34,640  
and it's going to fly through titan's

1233  
00:47:39,829 --> 00:47:36,800  
very thick atmosphere

1234  
00:47:42,150 --> 00:47:39,839  
and explore the surface of titan

1235  
00:47:44,630 --> 00:47:42,160  
now uh dragonfly is actually going to be

1236  
00:47:46,390 --> 00:47:44,640  
built right down the road from us at uh

1237  
00:47:48,309 --> 00:47:46,400  
hopkins applied physics laboratories so

1238  
00:47:50,309 --> 00:47:48,319

this will be very exciting um but it

1239

00:47:52,630 --> 00:47:50,319

won't be launched until 2027 so it's

1240

00:47:54,069 --> 00:47:52,640

something to look forward to but we

1241

00:47:56,069 --> 00:47:54,079

won't have

1242

00:47:57,829 --> 00:47:56,079

the beautiful pictures and the data for

1243

00:48:01,670 --> 00:47:57,839

a while so this is something to look

1244

00:48:03,670 --> 00:48:01,680

forward to in the longer term future

1245

00:48:04,710 --> 00:48:03,680

now you might be thinking to yourself

1246

00:48:07,030 --> 00:48:04,720

well

1247

00:48:09,190 --> 00:48:07,040

astrology seems more relevant to me

1248

00:48:10,710 --> 00:48:09,200

personally

1249

00:48:12,630 --> 00:48:10,720

but it turns out that astronomy and

1250

00:48:13,829 --> 00:48:12,640

astrophysics is very relevant to us

1251

00:48:16,230 --> 00:48:13,839

personally

1252

00:48:18,150 --> 00:48:16,240

and the reason is that mapping the

1253

00:48:20,950 --> 00:48:18,160

surfaces and atmospheres of jupiter and

1254

00:48:23,109 --> 00:48:20,960

saturn's moons can provide really

1255

00:48:24,950 --> 00:48:23,119

valuable information about where

1256

00:48:26,870 --> 00:48:24,960

extraterrestrial life might be able to

1257

00:48:28,790 --> 00:48:26,880

survive

1258

00:48:30,549 --> 00:48:28,800

and so if we delve into science fiction

1259

00:48:32,790 --> 00:48:30,559

a little bit and think back to again

1260

00:48:34,710 --> 00:48:32,800

december of this year there was a great

1261

00:48:35,750 --> 00:48:34,720

movie called the midnight sky that came

1262

00:48:37,670 --> 00:48:35,760

out

1263

00:48:39,510 --> 00:48:37,680

and george clooney plays an

1264

00:48:41,829 --> 00:48:39,520

astrophysicist

1265

00:48:44,710 --> 00:48:41,839

who is talking at the very beginning of

1266

00:48:47,349 --> 00:48:44,720

the movie to another scientist

1267

00:48:48,549 --> 00:48:47,359

who is exploring a habitable moon of

1268

00:48:50,549 --> 00:48:48,559

jupiter

1269

00:48:52,950 --> 00:48:50,559

now this is a fictional moon that in the

1270

00:48:54,950 --> 00:48:52,960

movie was discovered by george clooney's

1271

00:48:56,790 --> 00:48:54,960

astrophysicist character

1272

00:48:58,790 --> 00:48:56,800

uh but we can imagine you know that we

1273

00:49:01,829 --> 00:48:58,800

wouldn't find a potentially habitable

1274

00:49:03,670 --> 00:49:01,839

moon if we didn't go and search for it

1275

00:49:06,549 --> 00:49:03,680

and so this has some really interesting

1276

00:49:10,150 --> 00:49:06,559

again longer term implications for our

1277

00:49:15,109 --> 00:49:12,309

and this can this information is stuff

1278

00:49:17,750 --> 00:49:15,119

that can be applied to our study of

1279

00:49:20,630 --> 00:49:17,760

planets that orbit around other stars

1280

00:49:23,750 --> 00:49:20,640

so as of the end of august

1281

00:49:25,670 --> 00:49:23,760

scientists had confirmed about 4 500

1282

00:49:27,910 --> 00:49:25,680

planets orbiting around other stars so

1283

00:49:29,510 --> 00:49:27,920

this is really really exciting

1284

00:49:32,069 --> 00:49:29,520

and with the launch of the james webb

1285

00:49:35,109 --> 00:49:32,079

space telescope coming up soon

1286

00:49:37,030 --> 00:49:35,119

uh we'll really be able to take our

1287

00:49:38,470 --> 00:49:37,040

characterization of these planets to a

1288

00:49:40,470 --> 00:49:38,480

whole another level we'll be able to

1289

00:49:42,829 --> 00:49:40,480

look at their atmospheres much more

1290

00:49:45,910 --> 00:49:42,839

carefully um to understand the

1291

00:49:47,990 --> 00:49:45,920

composition and unfortunately it's much

1292

00:49:49,829 --> 00:49:48,000

harder to take pictures of the surface

1293

00:49:51,109 --> 00:49:49,839

of a planet around another star right

1294

00:49:52,309 --> 00:49:51,119

this is something that we don't really

1295

00:49:54,470 --> 00:49:52,319

have the

1296

00:49:56,549 --> 00:49:54,480

the capability to do yet

1297

00:49:58,470 --> 00:49:56,559

and so our work studying the moons of

1298

00:50:01,030 --> 00:49:58,480

saturn and jupiter is going to be really

1299

00:50:02,470 --> 00:50:01,040

valuable because it's

1300

00:50:04,390 --> 00:50:02,480

it's work that might be able to be

1301  
00:50:07,109 --> 00:50:04,400  
extended to studies of planets around

1302  
00:50:11,270 --> 00:50:09,510  
so this is one area where

1303  
00:50:13,910 --> 00:50:11,280  
there was a celestial event and the

1304  
00:50:16,549 --> 00:50:13,920  
roles of astronomers and astrophysicists

1305  
00:50:18,950 --> 00:50:16,559  
differed from roles of astrologers

1306  
00:50:21,990 --> 00:50:18,960  
now another event happened about four

1307  
00:50:23,190 --> 00:50:22,000  
years ago in 2017 with the total solar

1308  
00:50:25,190 --> 00:50:23,200  
eclipse

1309  
00:50:27,430 --> 00:50:25,200  
this was also described in the media the

1310  
00:50:29,670 --> 00:50:27,440  
as the great american eclipse because

1311  
00:50:32,470 --> 00:50:29,680  
the path of totality where you could see

1312  
00:50:35,349 --> 00:50:32,480  
the eclipse in its entirety uh crossed a

1313  
00:50:37,270 --> 00:50:35,359

very large swath of the united states

1314

00:50:39,109 --> 00:50:37,280

so i was living in colorado at the time

1315

00:50:42,069 --> 00:50:39,119

i was in grad school and so i drove up

1316

00:50:44,069 --> 00:50:42,079

to wyoming to watch it sat in horrific

1317

00:50:45,430 --> 00:50:44,079

traffic on the way back down to colorado

1318

00:50:47,190 --> 00:50:45,440

from wyoming

1319

00:50:49,670 --> 00:50:47,200

but it was really totally worth it it

1320

00:50:51,270 --> 00:50:49,680

was a magnificent site

1321

00:50:53,349 --> 00:50:51,280

and here we're looking at a picture of

1322

00:50:55,030 --> 00:50:53,359

totality so we're seeing the moon

1323

00:50:56,069 --> 00:50:55,040

completely blocking out the light from

1324

00:50:57,750 --> 00:50:56,079

the sun

1325

00:50:59,750 --> 00:50:57,760

and you'll notice that we are still

1326  
00:51:01,349 --> 00:50:59,760  
actually seeing some light here so this

1327  
00:51:03,030 --> 00:51:01,359  
is why you're not supposed to look at

1328  
00:51:04,870 --> 00:51:03,040  
any clips without your glasses because

1329  
00:51:07,349 --> 00:51:04,880  
the sun doesn't completely disappear and

1330  
00:51:09,349 --> 00:51:07,359  
even this residual light can hurt your

1331  
00:51:11,750 --> 00:51:09,359  
eyeballs

1332  
00:51:13,349 --> 00:51:11,760  
now again in the lead up to the total

1333  
00:51:16,230 --> 00:51:13,359  
solar eclipse

1334  
00:51:18,710 --> 00:51:16,240  
astrologers were assigning meaning to

1335  
00:51:20,230 --> 00:51:18,720  
the eclipse and predicting

1336  
00:51:22,710 --> 00:51:20,240  
what trying to make predictions about

1337  
00:51:25,109 --> 00:51:22,720  
how it would impact human behavior

1338  
00:51:27,750 --> 00:51:25,119

so we saw headlines about how the solar

1339

00:51:30,630 --> 00:51:27,760

eclipse could affect your sign

1340

00:51:32,309 --> 00:51:30,640

we also heard from astrologers who said

1341

00:51:34,630 --> 00:51:32,319

things like eclipses are the most

1342

00:51:37,430 --> 00:51:34,640

dramatic tools that the universe uses to

1343

00:51:39,589 --> 00:51:37,440

effect change nobody likes change but

1344

00:51:41,270 --> 00:51:39,599

eclipses shake us out of our complacency

1345

00:51:43,109 --> 00:51:41,280

and push us forward no matter if we're

1346

00:51:44,630 --> 00:51:43,119

ready or not

1347

00:51:46,309 --> 00:51:44,640

and this feature in time magazine

1348

00:51:48,390 --> 00:51:46,319

actually opened

1349

00:51:50,230 --> 00:51:48,400

by saying the upcoming total solar

1350

00:51:51,030 --> 00:51:50,240

eclipse will either wreak havoc on your

1351

00:51:53,670 --> 00:51:51,040

life

1352

00:51:55,430 --> 00:51:53,680

or herald waves of positive change that

1353

00:51:57,030 --> 00:51:55,440

is depending on who you are and which

1354

00:51:58,790 --> 00:51:57,040

astrologer you ask

1355

00:52:00,630 --> 00:51:58,800

and so remember you know we looked at

1356

00:52:02,390 --> 00:52:00,640

constellations across the globe and we

1357

00:52:05,750 --> 00:52:02,400

saw that the interpretations of the

1358

00:52:07,430 --> 00:52:05,760

patterns in the sky differed broadly

1359

00:52:09,589 --> 00:52:07,440

depending on

1360

00:52:11,430 --> 00:52:09,599

which uh which civilization we were

1361

00:52:13,829 --> 00:52:11,440

whose records we were looking at

1362

00:52:15,829 --> 00:52:13,839

um and the same holds true with

1363

00:52:18,309 --> 00:52:15,839

astrologers predictions as well there's

1364

00:52:20,790 --> 00:52:18,319

great variation in the interpretations

1365

00:52:23,109 --> 00:52:20,800

and the predictions

1366

00:52:25,589 --> 00:52:23,119

now astronomers and astrophysicists

1367

00:52:28,069 --> 00:52:25,599

instead used the total solar eclipse as

1368

00:52:31,349 --> 00:52:28,079

an opportunity to study the solar corona

1369

00:52:34,549 --> 00:52:31,359

or the crown of the sun

1370

00:52:37,829 --> 00:52:34,559

and so this image was taken with a

1371

00:52:39,109 --> 00:52:37,839

filter to extract particular wavelengths

1372

00:52:40,549 --> 00:52:39,119

of light

1373

00:52:42,710 --> 00:52:40,559

and if this may be a little bit hard to

1374

00:52:45,510 --> 00:52:42,720

see but they were able to detect these

1375

00:52:47,589 --> 00:52:45,520

big loops these plasma loops

1376  
00:52:50,950 --> 00:52:47,599  
and they were able to map structure and

1377  
00:52:52,870 --> 00:52:50,960  
holes in the solar corona

1378  
00:52:54,309 --> 00:52:52,880  
now this is really important and

1379  
00:52:57,270 --> 00:52:54,319  
interesting work

1380  
00:52:59,910 --> 00:52:57,280  
because we these loops can sometimes

1381  
00:53:01,670 --> 00:52:59,920  
turn into what are large coronal mass

1382  
00:53:03,430 --> 00:53:01,680  
ejections

1383  
00:53:05,030 --> 00:53:03,440  
and as very

1384  
00:53:07,910 --> 00:53:05,040  
catastrophically declared by this

1385  
00:53:09,910 --> 00:53:07,920  
headline that was in forbes

1386  
00:53:11,829 --> 00:53:09,920  
those coronal mass ejections can

1387  
00:53:14,790 --> 00:53:11,839  
potentially cause a multi-trillion

1388  
00:53:15,910 --> 00:53:14,800

dollar disaster they could potentially

1389

00:53:18,950 --> 00:53:15,920

wipe out

1390

00:53:21,910 --> 00:53:18,960

all of our technology leaving us kind of

1391

00:53:23,430 --> 00:53:21,920

very much in the dark

1392

00:53:25,349 --> 00:53:23,440

and so it's really important for

1393

00:53:27,589 --> 00:53:25,359

astronomers and astrophysicists to be

1394

00:53:28,630 --> 00:53:27,599

able to study the sun so that we can

1395

00:53:30,390 --> 00:53:28,640

understand

1396

00:53:32,630 --> 00:53:30,400

you know for example the likelihood of

1397

00:53:34,309 --> 00:53:32,640

an event like this happening

1398

00:53:36,790 --> 00:53:34,319

and maybe make some preparation so that

1399

00:53:39,109 --> 00:53:36,800

we're ready if it does

1400

00:53:42,549 --> 00:53:39,119

and so here we're looking at a picture

1401  
00:53:46,630 --> 00:53:42,559  
of the d-kist solar telescope which is

1402  
00:53:49,030 --> 00:53:46,640  
located on haleakala in maui in hawaii

1403  
00:53:51,430 --> 00:53:49,040  
and this beautiful picture here

1404  
00:53:53,270 --> 00:53:51,440  
was the first light image that was taken

1405  
00:53:55,190 --> 00:53:53,280  
from the dkis telescope and so this was

1406  
00:53:57,750 --> 00:53:55,200  
one of the first pictures that was ever

1407  
00:53:59,349 --> 00:53:57,760  
taken with this telescope and this is a

1408  
00:54:01,510 --> 00:53:59,359  
stunning image

1409  
00:54:03,190 --> 00:54:01,520  
so we can see all of these shapes that

1410  
00:54:05,750 --> 00:54:03,200  
look like cells

1411  
00:54:08,309 --> 00:54:05,760  
and these are called convection cells so

1412  
00:54:10,630 --> 00:54:08,319  
the convection cells transport energy

1413  
00:54:11,670 --> 00:54:10,640

from the interior of the sun to its

1414

00:54:14,230 --> 00:54:11,680

surface

1415

00:54:15,510 --> 00:54:14,240

and this is where those loops will

1416

00:54:17,270 --> 00:54:15,520

originate

1417

00:54:19,589 --> 00:54:17,280

and this also could be where those

1418

00:54:21,589 --> 00:54:19,599

coronal mass ejections might originate

1419

00:54:24,630 --> 00:54:21,599

so it's really important to map these

1420

00:54:26,870 --> 00:54:24,640

convection cells and there are lots of

1421

00:54:30,069 --> 00:54:26,880

solar astronomers and astrophysicists

1422

00:54:34,870 --> 00:54:32,790

now i've shown you where astronomers and

1423

00:54:38,230 --> 00:54:34,880

astrophysicists diverge from astrologers

1424

00:54:41,270 --> 00:54:38,240

for just a couple of celestial events

1425

00:54:43,109 --> 00:54:41,280

but this happens all of the time and so

1426  
00:54:45,589 --> 00:54:43,119  
maybe with the next celestial event that

1427  
00:54:47,589 --> 00:54:45,599  
comes up you'll be able to kind of see

1428  
00:54:52,069 --> 00:54:47,599  
what these differences are and

1429  
00:54:55,510 --> 00:54:54,069  
now we've really just scratched the

1430  
00:54:58,150 --> 00:54:55,520  
surface

1431  
00:54:59,750 --> 00:54:58,160  
of the history of studying the night sky

1432  
00:55:01,910 --> 00:54:59,760  
and so i want to leave you with a few

1433  
00:55:03,829 --> 00:55:01,920  
ways to think about this a little bit

1434  
00:55:05,190 --> 00:55:03,839  
more if you choose

1435  
00:55:06,710 --> 00:55:05,200  
so one thing you could do is you could

1436  
00:55:09,670 --> 00:55:06,720  
check out the work of cultural

1437  
00:55:11,910 --> 00:55:09,680  
astronomers like dr jorita holbrook

1438  
00:55:13,750 --> 00:55:11,920

dr holbrook is a professor at the

1439

00:55:14,789 --> 00:55:13,760

university of western cape in south

1440

00:55:17,430 --> 00:55:14,799

africa

1441

00:55:20,230 --> 00:55:17,440

and they work to understand astronomy in

1442

00:55:21,349 --> 00:55:20,240

an anthropological context across the

1443

00:55:23,270 --> 00:55:21,359

globe

1444

00:55:24,630 --> 00:55:23,280

and so they're really interested in

1445

00:55:26,470 --> 00:55:24,640

seeing how

1446

00:55:28,309 --> 00:55:26,480

the history of studying the night sky

1447

00:55:30,309 --> 00:55:28,319

and in particular civilization has

1448

00:55:32,789 --> 00:55:30,319

carried through to how people view

1449

00:55:34,230 --> 00:55:32,799

astronomy and astrophysics today

1450

00:55:35,990 --> 00:55:34,240

so her work is really fascinating and

1451

00:55:37,750 --> 00:55:36,000

she has an excellent ted talk that's

1452

00:55:40,230 --> 00:55:37,760

available on youtube that you can take a

1453

00:55:43,910 --> 00:55:41,910

and another thing that you can do is you

1454

00:55:45,990 --> 00:55:43,920

can explore the constellations that were

1455

00:55:48,710 --> 00:55:46,000

identified in other cultures

1456

00:55:51,190 --> 00:55:48,720

using this free app called stellarium

1457

00:55:52,870 --> 00:55:51,200

so you can download stellarium onto your

1458

00:55:53,910 --> 00:55:52,880

computer or you can have it on your

1459

00:55:56,870 --> 00:55:53,920

phone

1460

00:55:58,630 --> 00:55:56,880

and stellarium has this really neat star

1461

00:56:00,549 --> 00:55:58,640

lore tab

1462

00:56:03,510 --> 00:56:00,559

and if you click on the starlord tab

1463

00:56:05,270 --> 00:56:03,520

you'll see a whole menu

1464

00:56:06,630 --> 00:56:05,280

of uh

1465

00:56:07,990 --> 00:56:06,640

different

1466

00:56:10,069 --> 00:56:08,000

constellation

1467

00:56:12,230 --> 00:56:10,079

maps that you can pick and so you can

1468

00:56:15,030 --> 00:56:12,240

see what the constellations looked like

1469

00:56:17,910 --> 00:56:15,040

for aztec astronomers for chinese

1470

00:56:18,950 --> 00:56:17,920

astronomers egyptian native american

1471

00:56:20,309 --> 00:56:18,960

you can look at a whole bunch of

1472

00:56:21,829 --> 00:56:20,319

different cultures i think there's about

1473

00:56:23,349 --> 00:56:21,839

60 in here

1474

00:56:25,670 --> 00:56:23,359

and if you were to click on one of these

1475

00:56:28,069 --> 00:56:25,680

civilizations you would see

1476

00:56:29,750 --> 00:56:28,079

some information about

1477

00:56:32,230 --> 00:56:29,760

how those patterns were interpreted and

1478

00:56:34,069 --> 00:56:32,240

what constellations they used

1479

00:56:36,710 --> 00:56:34,079

and you'll also see references in here

1480

00:56:39,349 --> 00:56:36,720

and some contact information for places

1481

00:56:41,589 --> 00:56:39,359

where the archaeological work to

1482

00:56:43,829 --> 00:56:41,599

understand how people interpreted the

1483

00:56:45,030 --> 00:56:43,839

skies is still ongoing so if that's

1484

00:56:46,549 --> 00:56:45,040

something you're interested in that

1485

00:56:48,549 --> 00:56:46,559

could be a really neat way to get

1486

00:56:50,789 --> 00:56:48,559

involved

1487

00:56:53,190 --> 00:56:50,799

so i'll leave you with the final answer

1488

00:56:55,510 --> 00:56:53,200

to our big question

1489

00:56:57,510 --> 00:56:55,520

um and that is that both astronomers and

1490

00:57:00,390 --> 00:56:57,520

astrophysicists and astrologers make

1491

00:57:03,030 --> 00:57:00,400

very detailed maps of the sky so it's

1492

00:57:04,470 --> 00:57:03,040

our job to know what is up in the night

1493

00:57:06,069 --> 00:57:04,480

sky

1494

00:57:07,990 --> 00:57:06,079

and this allows us to determine when

1495

00:57:09,910 --> 00:57:08,000

astronomical events might happen so for

1496

00:57:11,430 --> 00:57:09,920

example eclipses and planetary

1497

00:57:13,109 --> 00:57:11,440

conjunctions

1498

00:57:15,589 --> 00:57:13,119

and for astronomers and astrophysicists

1499

00:57:17,750 --> 00:57:15,599

now this also lets us determine when

1500

00:57:20,470 --> 00:57:17,760

planets are going to be passing in front

1501  
00:57:22,950 --> 00:57:20,480  
of their host stars so exoplanets around

1502  
00:57:25,510 --> 00:57:22,960  
other stars

1503  
00:57:27,190 --> 00:57:25,520  
now astrologers exclusively use those

1504  
00:57:29,589 --> 00:57:27,200  
maps to make predictions about

1505  
00:57:31,990 --> 00:57:29,599  
individual human behavior and maybe

1506  
00:57:34,950 --> 00:57:32,000  
large-scale societal changes

1507  
00:57:36,870 --> 00:57:34,960  
so they really link the sky to human

1508  
00:57:38,789 --> 00:57:36,880  
behavior

1509  
00:57:42,069 --> 00:57:38,799  
and astronomers and astrophysicists we

1510  
00:57:44,549 --> 00:57:42,079  
do not do that so we use telescopes to

1511  
00:57:46,950 --> 00:57:44,559  
observe the night sky and collect data

1512  
00:57:49,030 --> 00:57:46,960  
and we also use computer simulations to

1513  
00:57:51,109 --> 00:57:49,040

investigate the physics that shapes our

1514

00:57:53,430 --> 00:57:51,119

universe and so we are really studying

1515

00:57:56,470 --> 00:57:53,440

astronomy and physics together to

1516

00:57:58,870 --> 00:57:56,480

understand how the universe works

1517

00:58:00,870 --> 00:57:58,880

so that brings us to the end of our time

1518

00:58:02,870 --> 00:58:00,880

together thank you so much for your

1519

00:58:06,950 --> 00:58:02,880

attention and i look forward to

1520

00:58:11,349 --> 00:58:09,270

thank you thank you that was wonderful

1521

00:58:14,390 --> 00:58:11,359

nice little um

1522

00:58:16,630 --> 00:58:14,400

both historical lesson as well as modern

1523

00:58:17,990 --> 00:58:16,640

uh interpretation of uh

1524

00:58:20,069 --> 00:58:18,000

of the um

1525

00:58:20,870 --> 00:58:20,079

the differences and uh

1526

00:58:23,990 --> 00:58:20,880

well

1527

00:58:25,829 --> 00:58:24,000

paying respect to the common origins of

1528

00:58:27,109 --> 00:58:25,839

studying the sky and how it

1529

00:58:29,190 --> 00:58:27,119

diverges

1530

00:58:31,270 --> 00:58:29,200

um i was particularly impressed when i

1531

00:58:33,349 --> 00:58:31,280

was listening to you um in

1532

00:58:37,190 --> 00:58:33,359

going through the the standard tico

1533

00:58:39,750 --> 00:58:37,200

brahi and johannes kepler and copernicus

1534

00:58:42,470 --> 00:58:39,760

and how the the sort of the divergence

1535

00:58:44,470 --> 00:58:42,480

happened as we started to go from

1536

00:58:46,390 --> 00:58:44,480

um i guess i sort of summarized it in my

1537

00:58:48,230 --> 00:58:46,400

own head that you know the astronomy and

1538

00:58:50,789 --> 00:58:48,240

the astrophysics went towards what are

1539

00:58:53,349 --> 00:58:50,799

the causes of what we see the changes in

1540

00:58:55,750 --> 00:58:53,359

the sky and the astrologers stayed with

1541

00:58:57,510 --> 00:58:55,760

well what are the effects of it you know

1542

00:58:59,829 --> 00:58:57,520

what do you think of that type uh

1543

00:59:01,190 --> 00:58:59,839

exactly exactly it was a very natural

1544

00:59:04,950 --> 00:59:01,200

progression

1545

00:59:07,349 --> 00:59:04,960

moving towards physics and causes

1546

00:59:09,030 --> 00:59:07,359

versus sticking with the effects

1547

00:59:10,710 --> 00:59:09,040

yeah

1548

00:59:13,990 --> 00:59:10,720

all right i'm going to bring in grant

1549

00:59:16,789 --> 00:59:14,000

justice grant has been monitoring our uh

1550

00:59:18,870 --> 00:59:16,799

chat there's been a bunch of stuff going

1551

00:59:20,710 --> 00:59:18,880

on on the chat um

1552

00:59:22,309 --> 00:59:20,720

grant uh why don't you turn on your

1553

00:59:24,870 --> 00:59:22,319

camera and join us

1554

00:59:26,950 --> 00:59:24,880

how things tonight grant hello yeah

1555

00:59:28,710 --> 00:59:26,960

we've had quite a lively chat tonight

1556

00:59:29,589 --> 00:59:28,720

it's been quite good

1557

00:59:31,190 --> 00:59:29,599

um

1558

00:59:34,549 --> 00:59:31,200

all right so

1559

00:59:36,309 --> 00:59:34,559

let me see what we got going on here

1560

00:59:37,589 --> 00:59:36,319

all right so we'll start us off first

1561

00:59:40,150 --> 00:59:37,599

with a good one

1562

00:59:43,349 --> 00:59:40,160

um is there an astronomy-based

1563

00:59:47,990 --> 00:59:43,359

alternative to astrology birth signs

1564

00:59:53,589 --> 00:59:51,670

that is a very excellent

1565

00:59:57,430 --> 00:59:53,599

question

1566

01:00:03,190 --> 01:00:00,470

okay so the short answer is no

1567

01:00:06,630 --> 01:00:03,200

um but that's because the birth signs

1568

01:00:07,990 --> 01:00:06,640

were defined based on what astronomy was

1569

01:00:09,589 --> 01:00:08,000

at the time

1570

01:00:11,670 --> 01:00:09,599

so the constellations that make up the

1571

01:00:13,349 --> 01:00:11,680

zodiac that are used as birth signs are

1572

01:00:14,470 --> 01:00:13,359

very real constellations so you can look

1573

01:00:16,309 --> 01:00:14,480

out at the night sky and you can

1574

01:00:18,069 --> 01:00:16,319

actually you can see them

1575

01:00:20,309 --> 01:00:18,079

um but the difference is that

1576

01:00:23,349 --> 01:00:20,319

astronomers today

1577

01:00:25,270 --> 01:00:23,359

don't use those as birth signs um they

1578

01:00:27,670 --> 01:00:25,280

provide a map of the universe for where

1579

01:00:29,109 --> 01:00:27,680

things are so for example i study star

1580

01:00:32,069 --> 01:00:29,119

and planet formation

1581

01:00:34,549 --> 01:00:32,079

and so i think a lot about what we call

1582

01:00:35,510 --> 01:00:34,559

the taurus association

1583

01:00:37,510 --> 01:00:35,520

and so

1584

01:00:39,750 --> 01:00:37,520

the taurus constellation

1585

01:00:41,349 --> 01:00:39,760

is important to me because it tells me

1586

01:00:43,510 --> 01:00:41,359

where my

1587

01:00:44,870 --> 01:00:43,520

targets are

1588

01:00:45,589 --> 01:00:44,880

whereas

1589

01:00:57,510 --> 01:00:45,599

i

1590

01:00:59,190 --> 01:00:57,520

mean what uh

1591

01:01:00,390 --> 01:00:59,200

the position of the sky on the day you

1592

01:01:01,349 --> 01:01:00,400

were born

1593

01:01:07,190 --> 01:01:01,359

um

1594

01:01:09,109 --> 01:01:07,200

effect of that

1595

01:01:11,190 --> 01:01:09,119

right and we're really you know trying

1596

01:01:12,150 --> 01:01:11,200

to look at the physics behind it and so

1597

01:01:15,190 --> 01:01:12,160

um

1598

01:01:16,390 --> 01:01:15,200

as uh i think carl sagan put it once you

1599

01:01:18,390 --> 01:01:16,400

know the um

1600

01:01:20,309 --> 01:01:18,400

the the person delivering you at your

1601  
01:01:25,349 --> 01:01:20,319  
birth has a stronger gravitational

1602  
01:01:27,030 --> 01:01:25,359  
effect than any star um in the night sky

1603  
01:01:28,789 --> 01:01:27,040  
and you mentioned that the scientific

1604  
01:01:31,510 --> 01:01:28,799  
method frank so one place where this

1605  
01:01:34,069 --> 01:01:31,520  
diverges is that um as astronomers and

1606  
01:01:36,390 --> 01:01:34,079  
astrophysicists we are looking to make

1607  
01:01:38,069 --> 01:01:36,400  
testable predictions exactly um and so

1608  
01:01:40,789 --> 01:01:38,079  
the thing that's difficult with birth

1609  
01:01:43,030 --> 01:01:40,799  
signs is that you can't be born twice

1610  
01:01:45,030 --> 01:01:43,040  
um and so that

1611  
01:01:46,789 --> 01:01:45,040  
makes it difficult for that to be a

1612  
01:01:49,349 --> 01:01:46,799  
testable prediction so that's where our

1613  
01:01:50,789 --> 01:01:49,359

work diverges from the astrologers

1614

01:01:52,549 --> 01:01:50,799

okay

1615

01:01:54,309 --> 01:01:52,559

all right grant we have another question

1616

01:01:55,990 --> 01:01:54,319

from online yeah

1617

01:01:57,349 --> 01:01:56,000

absolutely i'm gonna throw this one in

1618

01:01:59,750 --> 01:01:57,359

there while i'm looking for the other

1619

01:02:02,710 --> 01:01:59,760

questions uh a super important one from

1620

01:02:04,150 --> 01:02:02,720

a viewer how many marathons have you run

1621

01:02:05,670 --> 01:02:04,160

oh

1622

01:02:06,630 --> 01:02:05,680

i feel like i'm on the spot i have run

1623

01:02:09,190 --> 01:02:06,640

one

1624

01:02:11,109 --> 01:02:09,200

it went very badly

1625

01:02:12,710 --> 01:02:11,119

so i am actually really excited to run

1626

01:02:14,470 --> 01:02:12,720

the marathon at the baltimore running

1627

01:02:15,990 --> 01:02:14,480

festival in october and hopefully that

1628

01:02:17,670 --> 01:02:16,000

goes better but at the very least it

1629

01:02:21,510 --> 01:02:17,680

will be a great way to kind of see the

1630

01:02:25,349 --> 01:02:23,190

all right very good

1631

01:02:27,270 --> 01:02:25,359

i'll just note that we've had a quite a

1632

01:02:28,870 --> 01:02:27,280

a history of um

1633

01:02:31,190 --> 01:02:28,880

runners at the space telescope science

1634

01:02:32,710 --> 01:02:31,200

institute if when you actually get to go

1635

01:02:35,190 --> 01:02:32,720

into the building you can see the

1636

01:02:37,829 --> 01:02:35,200

plaques that are up by the uh cafe

1637

01:02:40,549 --> 01:02:37,839

of the uh the runners uh and the team

1638

01:02:42,230 --> 01:02:40,559

plaques that they won over the years so

1639

01:02:43,910 --> 01:02:42,240

oh yes i can't wait there's a lively

1640

01:02:48,789 --> 01:02:43,920

community in slack but it'll be great to

1641

01:02:52,789 --> 01:02:50,630

i'm sourcing a couple more questions

1642

01:02:54,549 --> 01:02:52,799

here we you did a good job of answering

1643

01:02:57,190 --> 01:02:54,559

most of them in your talk already so

1644

01:02:58,870 --> 01:02:57,200

that's that's a positive thing okay so

1645

01:03:00,309 --> 01:02:58,880

while while you search grant let me just

1646

01:03:02,470 --> 01:03:00,319

um mention

1647

01:03:04,789 --> 01:03:02,480

nicole i remember um

1648

01:03:05,910 --> 01:03:04,799

and i was teaching a a solar system

1649

01:03:08,390 --> 01:03:05,920

class

1650

01:03:10,710 --> 01:03:08,400

researching kepler's books

1651

01:03:13,109 --> 01:03:10,720

and being surprised by just how much

1652

01:03:15,829 --> 01:03:13,119

numerology actually was in it

1653

01:03:19,589 --> 01:03:15,839

uh kepler was really really looking for

1654

01:03:21,990 --> 01:03:19,599

mathematical patterns um and he just

1655

01:03:24,390 --> 01:03:22,000

went off the deep end in terms of the

1656

01:03:26,549 --> 01:03:24,400

the the ways the patterns have you have

1657

01:03:30,390 --> 01:03:26,559

you looked at any of that

1658

01:03:32,309 --> 01:03:30,400

i i haven't read his books too carefully

1659

01:03:34,549 --> 01:03:32,319

but you know i've always been fascinated

1660

01:03:36,069 --> 01:03:34,559

by how he came up

1661

01:03:37,990 --> 01:03:36,079

with his laws

1662

01:03:40,710 --> 01:03:38,000

um you know the one that we think about

1663

01:03:42,870 --> 01:03:40,720

when we talk about planetary orbits is

1664

01:03:44,870 --> 01:03:42,880

the relationship between the period or

1665

01:03:45,990 --> 01:03:44,880

how long it takes a planet to go around

1666

01:03:47,910 --> 01:03:46,000

its star

1667

01:03:48,950 --> 01:03:47,920

and the distance between the planet and

1668

01:03:52,150 --> 01:03:48,960

the star

1669

01:03:56,230 --> 01:03:52,160

and kepler's rule that he discovered

1670

01:03:58,470 --> 01:03:56,240

was that uh the square of the period so

1671

01:04:02,789 --> 01:03:58,480

this time squared

1672

01:04:04,950 --> 01:04:02,799

was proportional to the distance cubed

1673

01:04:06,230 --> 01:04:04,960

now this is this is very weird right i

1674

01:04:08,150 --> 01:04:06,240

don't like thinking about things that

1675

01:04:10,870 --> 01:04:08,160

are squared and cubed

1676

01:04:13,829 --> 01:04:10,880

in my head when i know what the math is

1677

01:04:16,230 --> 01:04:13,839

and so i can only imagine the rabbit

1678

01:04:18,870 --> 01:04:16,240

holes that he went down you know to cut

1679

01:04:21,510 --> 01:04:18,880

to identify these patterns it was really

1680

01:04:24,150 --> 01:04:21,520

really remarkable science

1681

01:04:26,150 --> 01:04:24,160

right and he went down a lot of rabbit

1682

01:04:28,069 --> 01:04:26,160

holes that didn't lead anywhere which is

1683

01:04:31,270 --> 01:04:28,079

what i found in my research it was like

1684

01:04:33,910 --> 01:04:31,280

okay uh but this that to me that marked

1685

01:04:35,990 --> 01:04:33,920

really the divergence from uh getting to

1686

01:04:37,510 --> 01:04:36,000

the physical explanations um and trying

1687

01:04:41,670 --> 01:04:37,520

to just come up with these empirical

1688

01:04:43,270 --> 01:04:41,680

laws that fit these things um so almost

1689

01:04:45,670 --> 01:04:43,280

interesting time in the history of

1690

01:04:46,710 --> 01:04:45,680

astronomy and it was really clear that

1691

01:04:48,710 --> 01:04:46,720

you know his background as a

1692

01:04:51,029 --> 01:04:48,720

mathematician was really what allowed

1693

01:04:52,390 --> 01:04:51,039

him to find this pattern and identify

1694

01:04:54,230 --> 01:04:52,400

this connection

1695

01:04:56,549 --> 01:04:54,240

so there's definitely a lot of overlap

1696

01:04:58,630 --> 01:04:56,559

between astronomy and astrophysics and

1697

01:05:01,510 --> 01:04:58,640

with physics and math

1698

01:05:02,710 --> 01:05:01,520

and now chemistry too is worth it

1699

01:05:04,309 --> 01:05:02,720

i mean

1700

01:05:05,750 --> 01:05:04,319

i'm sure you get a lot of kids asking

1701

01:05:07,349 --> 01:05:05,760

you well what do i need to study to

1702

01:05:08,870 --> 01:05:07,359

become an astronomer and

1703

01:05:10,309 --> 01:05:08,880

really you need to have your math before

1704

01:05:11,670 --> 01:05:10,319

you can have your physics and you have

1705

01:05:14,549 --> 01:05:11,680

your physics before you can do your

1706

01:05:17,510 --> 01:05:14,559

astronomy uh so it's it's really this

1707

01:05:20,470 --> 01:05:17,520

layer cake of building up to get to

1708

01:05:22,549 --> 01:05:20,480

these things and it all comes together

1709

01:05:23,829 --> 01:05:22,559

grant we've been vamping go ahead

1710

01:05:26,789 --> 01:05:23,839

sure um

1711

01:05:28,630 --> 01:05:26,799

i actually like this one so having given

1712

01:05:31,349 --> 01:05:28,640

your talk and done the research on it

1713

01:05:35,349 --> 01:05:31,359

what would you consider the benefit

1714

01:05:40,950 --> 01:05:38,870

that's also a very good question

1715

01:05:44,230 --> 01:05:40,960

i don't think there's anything

1716

01:05:48,789 --> 01:05:44,240

bad about people feeling good

1717

01:05:50,470 --> 01:05:48,799

um and so people across the world really

1718

01:05:53,349 --> 01:05:50,480

put a lot of faith

1719

01:05:56,150 --> 01:05:53,359

in astrologers to make predictions that

1720

01:05:57,190 --> 01:05:56,160

might dictate the course of their lives

1721

01:05:59,190 --> 01:05:57,200

um and

1722

01:06:01,270 --> 01:05:59,200

i think that can be very dangerous right

1723

01:06:03,029 --> 01:06:01,280

you know you can be a dangerous thing to

1724

01:06:04,789 --> 01:06:03,039

give somebody else control over your

1725

01:06:05,750 --> 01:06:04,799

life

1726

01:06:07,589 --> 01:06:05,760

but

1727

01:06:09,670 --> 01:06:07,599

it's very clear that sometimes those

1728

01:06:11,029 --> 01:06:09,680

predictions can give people a sense of

1729

01:06:13,029 --> 01:06:11,039

peace

1730

01:06:15,349 --> 01:06:13,039

and maybe some security

1731

01:06:16,470 --> 01:06:15,359

in having a path that's charted out

1732

01:06:18,309 --> 01:06:16,480

and

1733

01:06:19,990 --> 01:06:18,319

i don't think there's anything wrong

1734

01:06:21,349 --> 01:06:20,000

with that it's not what i do as an

1735

01:06:22,390 --> 01:06:21,359

astronomer

1736

01:06:24,470 --> 01:06:22,400

um

1737

01:06:26,789 --> 01:06:24,480

but i i think that's something that's

1738

01:06:29,510 --> 01:06:26,799

positive you know you can never go wrong

1739

01:06:31,750 --> 01:06:29,520

with people feeling good

1740

01:06:33,349 --> 01:06:31,760

i would also say that um i have a number

1741

01:06:36,470 --> 01:06:33,359

of friends who just treat it as

1742

01:06:39,109 --> 01:06:36,480

entertainment okay it's uh you know

1743

01:06:41,430 --> 01:06:39,119

they don't uh take it too seriously um

1744

01:06:43,430 --> 01:06:41,440

but they check their horoscope sometimes

1745

01:06:45,109 --> 01:06:43,440

in terms of uh

1746

01:06:47,510 --> 01:06:45,119

treating it as as an entertainment

1747

01:06:48,870 --> 01:06:47,520

device uh for that and there's nothing

1748

01:06:49,829 --> 01:06:48,880

we've got plenty of inter and plenty of

1749

01:06:53,029 --> 01:06:49,839

ways to

1750

01:06:55,750 --> 01:06:54,549

but very important to keep the

1751

01:06:57,270 --> 01:06:55,760

distinction

1752

01:06:59,510 --> 01:06:57,280

exactly yes

1753

01:07:00,630 --> 01:06:59,520

and that's where the you know hollywood

1754

01:07:02,150 --> 01:07:00,640

and other

1755

01:07:04,069 --> 01:07:02,160

forms of entertainment

1756

01:07:06,069 --> 01:07:04,079

blur the lines between them um

1757

01:07:07,670 --> 01:07:06,079

unfortunately

1758

01:07:08,950 --> 01:07:07,680

exactly yeah

1759

01:07:12,069 --> 01:07:08,960

agreed

1760

01:07:13,589 --> 01:07:12,079

the chat has just been backing up most

1761

01:07:15,430 --> 01:07:13,599

of the things that you've said already

1762

01:07:17,670 --> 01:07:15,440

we really don't have too terribly many

1763

01:07:20,309 --> 01:07:17,680

questions so far

1764

01:07:24,549 --> 01:07:20,319

so okay

1765

01:07:27,510 --> 01:07:25,670

well

1766

01:07:30,069 --> 01:07:27,520

i mean one of the things that's oh there

1767

01:07:32,230 --> 01:07:30,079

was a question about the zodiacal light

1768

01:07:35,349 --> 01:07:32,240

um you mentioned the constellations the

1769

01:07:37,829 --> 01:07:35,359

the the the constellations of the zodiac

1770

01:07:39,510 --> 01:07:37,839

can you talk about zodiacal light and

1771

01:07:41,670 --> 01:07:39,520

does this have any relevance to

1772

01:07:43,109 --> 01:07:41,680

astrology or the constellations of the

1773

01:07:48,069 --> 01:07:43,119

zodiac

1774

01:07:50,390 --> 01:07:48,079

bit different as far as i know

1775

01:07:52,950 --> 01:07:50,400

they're the astrology does not

1776

01:07:54,870 --> 01:07:52,960

incorporate the zediaco light

1777

01:07:57,750 --> 01:07:54,880

um and so this is light that's kind of

1778

01:08:00,230 --> 01:07:57,760

scattered off of very small dust grains

1779

01:08:02,390 --> 01:08:00,240

in the solar system i mean it's very

1780

01:08:03,750 --> 01:08:02,400

very hard to see so i personally have

1781

01:08:06,950 --> 01:08:03,760

never seen it you have to go somewhere

1782

01:08:09,349 --> 01:08:06,960

where the skies are very very dark

1783

01:08:11,510 --> 01:08:09,359

but it is not

1784

01:08:13,829 --> 01:08:11,520

directly connected to the constellations

1785

01:08:17,189 --> 01:08:13,839

in any way i'm actually not sure of the

1786

01:08:18,309 --> 01:08:17,199

origin of the name zodiacal dust

1787

01:08:19,189 --> 01:08:18,319

um

1788

01:08:20,550 --> 01:08:19,199

i would

1789

01:08:22,630 --> 01:08:20,560

my guess was that you know it's in the

1790

01:08:25,430 --> 01:08:22,640

plane of the ecliptic basically right

1791

01:08:27,430 --> 01:08:25,440

yes and the constellations of the zodiac

1792

01:08:29,430 --> 01:08:27,440

are going to be you know in the plane of

1793

01:08:31,030 --> 01:08:29,440

the ecliptic so that the only place

1794

01:08:31,829 --> 01:08:31,040

you're going to see the zodiacal light

1795

01:08:33,430 --> 01:08:31,839

is

1796

01:08:34,950 --> 01:08:33,440

along the ecliptic

1797

01:08:36,550 --> 01:08:34,960

in the constellations of the zodiac i

1798

01:08:38,309 --> 01:08:36,560

get was my

1799

01:08:40,229 --> 01:08:38,319

guess understanding i haven't studied

1800

01:08:42,470 --> 01:08:40,239

the zodiac light myself

1801

01:08:44,309 --> 01:08:42,480

so it's quite possible that in early

1802

01:08:46,309 --> 01:08:44,319

times you know it was easier to see the

1803

01:08:48,870 --> 01:08:46,319

zodiacal light without the pollution

1804

01:08:51,430 --> 01:08:48,880

that we have from our cities now

1805

01:08:54,229 --> 01:08:51,440

um but i as far as i know it is not

1806

01:08:55,990 --> 01:08:54,239

incorporated in astrology

1807

01:08:58,149 --> 01:08:56,000

i mean when i was researching the story

1808

01:08:59,829 --> 01:08:58,159

that we did on the great comet today

1809

01:09:01,829 --> 01:08:59,839

i was like look at all these great

1810

01:09:04,229 --> 01:09:01,839

comments that occurred oh yeah this was

1811

01:09:06,070 --> 01:09:04,239

before we had the light bulb of course

1812

01:09:07,510 --> 01:09:06,080

you know

1813

01:09:09,430 --> 01:09:07,520

there could be great comments because

1814

01:09:10,630 --> 01:09:09,440

you could actually see them in the dark

1815

01:09:15,110 --> 01:09:10,640

night skies

1816

01:09:16,630 --> 01:09:15,120

exactly yeah it really made a difference

1817

01:09:20,950 --> 01:09:16,640

okay grant do we have anything else on

1818

01:09:25,510 --> 01:09:24,149

no we're good on the chat so

1819

01:09:26,630 --> 01:09:25,520

fantastic

1820

01:09:28,789 --> 01:09:26,640

um

1821

01:09:30,229 --> 01:09:28,799

well thank you very much nicole that was

1822

01:09:33,430 --> 01:09:30,239

a wonderful talk

1823

01:09:37,430 --> 01:09:33,440

next month we will have todd lauer

1824

01:09:39,510 --> 01:09:37,440

talking about how dark is the night sky