PUBLIC LECTURE SERIES

# Cloudy with a Chance of Stars

Featuring Guest Speaker:
**Nimisha Kumari**

1
00:00:00,000 --> 00:00:02,960
and we'll start

2
00:00:07,040 --> 00:00:04,640
good evening ladies and gentlemen and

3
00:00:09,590 --> 00:00:07,050
welcome to the Space Telescope public

4
00:00:11,240 --> 00:00:09,600
lecture series I'm your host dr. Frank

5
00:00:14,360 --> 00:00:11,250
summers of the office of public outreach

6
00:00:16,220 --> 00:00:14,370
here if you did not get one on the way

7
00:00:18,470 --> 00:00:16,230
in please grab one on the way out we

8
00:00:21,710 --> 00:00:18,480
have our lithographs here

9
00:00:26,269 --> 00:00:21,720
and tonight's lithograph is the

10
00:00:27,890 --> 00:00:26,279
star-forming nebula NGC 3603 a good

11
00:00:30,290 --> 00:00:27,900
friend of mine yeah actually I don't

12
00:00:32,359 --> 00:00:30,300
remember anything about 3603 we did the

13
00:00:35,000 --> 00:00:32,369

press release on this back in I don't

14
00:00:37,160 --> 00:00:35,010
know how many years ago so if I wanted

15
00:00:40,490 --> 00:00:37,170
to learn about it what would I do I turn

16
00:00:41,779 --> 00:00:40,500
over on the back and I'd read the 350

17
00:00:43,910 --> 00:00:41,789
words were allowed to put on the back of

18
00:00:47,119 --> 00:00:43,920
our lithographs which I'll tell you

19
00:00:49,610 --> 00:00:47,129
about the several evolution that happens

20
00:00:52,939 --> 00:00:49,620
when you look into these star forming

21
00:00:55,790 --> 00:00:52,949
clusters okay grab one on your way out

22
00:00:58,160 --> 00:00:55,800
if you didn't get one all right we have

23
00:01:00,500 --> 00:00:58,170
to do this in the electronic age silence

24
00:01:03,170 --> 00:01:00,510
your phones turn off their ringtones and

25
00:01:05,030 --> 00:01:03,180
the text notifications and those camera

26
00:01:08,780 --> 00:01:05,040
clicks and everything thank you very

27
00:01:11,960 --> 00:01:08,790
much tonight our speaker is Nimisha

28
00:01:15,590 --> 00:01:11,970
Kumari our talk is Cloudy with a Chance

29
00:01:18,230 --> 00:01:15,600
of stars sort of a playoff Cloudy with a

30
00:01:22,220 --> 00:01:18,240
Chance of Meatballs which would be the

31
00:01:24,200 --> 00:01:22,230
NASA meatball of course right all right

32
00:01:27,440 --> 00:01:24,210
it will be about some star formation

33
00:01:30,320 --> 00:01:27,450
which is why I chose NGC 3603 as our

34
00:01:32,270 --> 00:01:30,330
thing next month I will be giving the

35
00:01:34,340 --> 00:01:32,280
talk on some recent work that we did on

36
00:01:36,760 --> 00:01:34,350
the crab nebula we made a beautiful

37
00:01:39,350 --> 00:01:36,770
visual 3-dimensional multi-wavelength

38
00:01:41,510 --> 00:01:39,360

visualization of the Crab Nebula

39
00:01:45,050 --> 00:01:41,520
but I'll couple that with discussions of

40
00:01:48,440 --> 00:01:45,060
supernovae things that go kaboom in the

41
00:01:50,890 --> 00:01:48,450
night in March we have exoplanets a

42
00:01:55,820 --> 00:01:50,900
search for new worlds by Nestor Espinoza

43
00:01:56,900 --> 00:01:55,830
and in April we will have a talk on 30

44
00:02:02,030 --> 00:01:56,910
years of the Hubble Space Telescope

45
00:02:06,320 --> 00:02:02,040
Hubble hits 30 on April 24th 2020 yeah

46
00:02:08,029 --> 00:02:06,330
30 years ago and the folks who are doing

47
00:02:09,979 --> 00:02:08,039
who are organizing this

48
00:02:11,120 --> 00:02:09,989
have not committed to a single speaker

49
00:02:13,100 --> 00:02:11,130
but they said Oh we'll probably

50
00:02:15,590 --> 00:02:13,110
round-robin it so I just called them an

51
00:02:18,170 --> 00:02:15,600
all-star cast from the Space Telescope

52
00:02:23,839 --> 00:02:21,339
let's see as you all who are here

53
00:02:25,940 --> 00:02:23,849
recognize there is building construction

54
00:02:28,100 --> 00:02:25,950
going on the lobby is being totally

55
00:02:29,780 --> 00:02:28,110
redesigned at least January February

56
00:02:31,220 --> 00:02:29,790
March public lectures you will have to

57
00:02:33,920 --> 00:02:31,230
use this side entrance that you use

58
00:02:35,960 --> 00:02:33,930
tonight everyone found it ok I put up

59
00:02:38,569 --> 00:02:35,970
some signs to make sure it's going all

60
00:02:42,710 --> 00:02:38,579
right wow there's a lot of people here

61
00:02:44,509 --> 00:02:42,720
for January all right this is great

62
00:02:46,910 --> 00:02:44,519
I'm not used to sort audience being this

63
00:02:50,509 --> 00:02:46,920

full in January and they made sure you

64
00:02:51,949 --> 00:02:50,519
obviously packed them in tonight so we

65
00:02:54,530 --> 00:02:51,959
use the end of the entrance the signs

66
00:02:56,539 --> 00:02:54,540
were posted and if anybody needs

67
00:02:59,360 --> 00:02:56,549
wheelchair access please contact us

68
00:03:01,849 --> 00:02:59,370
before we will do our best to make sure

69
00:03:05,240 --> 00:03:01,859
that that is possible okay all right

70
00:03:06,770 --> 00:03:05,250
let's see our website where you can find

71
00:03:11,330 --> 00:03:06,780
the list of the upcoming lectures as

72
00:03:13,220 --> 00:03:11,340
they go we have our webcasts here both

73
00:03:17,210 --> 00:03:13,230
on YouTube and our Space Telescope

74
00:03:21,199 --> 00:03:17,220
webcast archive the webcast archive goes

75
00:03:24,020 --> 00:03:21,209
back to 2005 back to when it was only

76
00:03:25,819 --> 00:03:24,030
Hubble's 15th anniversary right around

77
00:03:28,640 --> 00:03:25,829
Hubble's 15th anniversary when we did

78
00:03:30,170 --> 00:03:28,650
our first archived webcast the youtube

79
00:03:33,349 --> 00:03:30,180
playlist goes back about three or four

80
00:03:36,619 --> 00:03:33,359
years or five years if you would like to

81
00:03:38,750 --> 00:03:36,629
get emails wrong one there we go if you

82
00:03:40,640 --> 00:03:38,760
like to hit emails you can sign up right

83
00:03:43,460 --> 00:03:40,650
here just enter your email address hit

84
00:03:45,770 --> 00:03:43,470
that button subscribe and it will add

85
00:03:48,589 --> 00:03:45,780
you to the lecture

86
00:03:51,199 --> 00:03:48,599
email list also on our website are the

87
00:03:53,599 --> 00:03:51,209
list of the upcoming lectures alright

88
00:03:56,390 --> 00:03:53,609

and you've got the various lectures

89
00:03:58,670 --> 00:03:56,400
these are old ones and for each lecture

90
00:04:01,280 --> 00:03:58,680
if you click down on it you get all the

91
00:04:03,979 --> 00:04:01,290
details including you know the abstract

92
00:04:06,470 --> 00:04:03,989
of what's going on they have the view

93
00:04:10,250 --> 00:04:06,480
the webcast on the SDI say I webcast and

94
00:04:13,099 --> 00:04:10,260
down here is the webcast on YouTube okay

95
00:04:15,860 --> 00:04:13,109
so you can see use that as a way to find

96
00:04:17,870 --> 00:04:15,870
all of the old lecture make sure

97
00:04:22,610 --> 00:04:17,880
everyone knows the email address of the

98
00:04:27,110 --> 00:04:22,620
URL is stsci - edu public - lectures

99
00:04:29,180 --> 00:04:27,120
alright email as I said sign up at the

100
00:04:30,150 --> 00:04:29,190
website but there are still some people

101
00:04:32,700 --> 00:04:30,160
including one

102
00:04:34,310 --> 00:04:32,710
night so I have an email address written

103
00:04:39,450 --> 00:04:34,320
right here that I will add to the list

104
00:04:42,960 --> 00:04:39,460
tomorrow I don't work I'm quite happy to

105
00:04:44,310 --> 00:04:42,970
take analogue submissions if you have

106
00:04:48,750 --> 00:04:44,320
comments and questions you can send them

107
00:04:51,090 --> 00:04:48,760
to public lecture at STScI dot edu our

108
00:04:54,060 --> 00:04:51,100
social media for hubble of the James

109
00:04:55,950 --> 00:04:54,070
Webb Space Telescope and 4stsc is as an

110
00:04:58,890 --> 00:04:55,960
entity are available Facebook Twitter

111
00:05:00,660 --> 00:04:58,900
YouTube and Instagram myself I do a

112
00:05:03,840 --> 00:05:00,670
little bit of work on Facebook and

113
00:05:06,180 --> 00:05:03,850

Twitter all right

114
00:05:07,800 --> 00:05:06,190
the observatory is not gonna be open

115
00:05:10,260 --> 00:05:07,810
tonight I think you might have noticed

116
00:05:13,380 --> 00:05:10,270
as you were coming in that it's not a

117
00:05:18,360 --> 00:05:13,390
clear night tonight but you can go to

118
00:05:20,250 --> 00:05:18,370
this Web website MD dot space grant o RG

119
00:05:22,110 --> 00:05:20,260
and you'll find this page of the

120
00:05:24,780 --> 00:05:22,120
Maryland space grant observatory open

121
00:05:27,480 --> 00:05:24,790
houses and right here is the observatory

122
00:05:29,790 --> 00:05:27,490
status and every Friday you know after

123
00:05:31,650 --> 00:05:29,800
5:00 p.m. they will have that updated as

124
00:05:34,470 --> 00:05:31,660
to whether they are opening and you can

125
00:05:34,710 --> 00:05:34,480
come look through the telescope then all

126
00:05:38,100 --> 00:05:34,720
right

127
00:05:41,730 --> 00:05:38,110
and now our news from the universe for

128
00:05:43,560 --> 00:05:41,740
January 2020 our first story tonight

129
00:05:46,200 --> 00:05:43,570
comes from the American Astronomical

130
00:05:47,790 --> 00:05:46,210
Society meeting that was held last week

131
00:05:50,370 --> 00:05:47,800
the reason why we're here on the second

132
00:05:52,980 --> 00:05:50,380
Tuesday tonight is because the double-a

133
00:05:55,170 --> 00:05:52,990
s meeting was last week and a good

134
00:05:57,659 --> 00:05:55,180
portion of folks including myself were

135
00:06:00,630 --> 00:05:57,669
there at the meeting at the meeting we

136
00:06:02,730 --> 00:06:00,640
talked about a gentle giant galaxy all

137
00:06:06,150 --> 00:06:02,740
right so let's start with the Virgo

138
00:06:08,610 --> 00:06:06,160

cluster this is the largest cluster of

139
00:06:10,440 --> 00:06:08,620
galaxies in the nearby universe and

140
00:06:12,030 --> 00:06:10,450
actually this isn't the whole Virgo

141
00:06:14,130 --> 00:06:12,040
cluster this is just the core of the

142
00:06:17,130 --> 00:06:14,140
Virgo cluster Virgo totally contains

143
00:06:19,770 --> 00:06:17,140
about 2,000 galaxies I mean it's just a

144
00:06:22,200 --> 00:06:19,780
massive this is this is New York City of

145
00:06:23,850 --> 00:06:22,210
galaxies okay the galaxies is they're

146
00:06:27,030 --> 00:06:23,860
congregating in this metropolis all

147
00:06:28,950 --> 00:06:27,040
right and we did a survey at one time

148
00:06:31,050 --> 00:06:28,960
looking at the galaxies and trying to

149
00:06:34,260 --> 00:06:31,060
determine and then we put out this image

150
00:06:36,330 --> 00:06:34,270
here which had all the galaxies some

151
00:06:39,779 --> 00:06:36,340
well about a hundred galaxies in the

152
00:06:42,480 --> 00:06:39,789
Virgo cluster put on the same scale on

153
00:06:43,860 --> 00:06:42,490
the same image now what do you notice

154
00:06:46,110 --> 00:06:43,870
about the largest

155
00:06:49,100 --> 00:06:46,120
galaxies the largest galaxies that are

156
00:06:53,010 --> 00:06:49,110
up here at the top row okay

157
00:06:55,350 --> 00:06:53,020
they tend to be elliptical galaxies

158
00:06:57,120 --> 00:06:55,360
right and matter of fact there is a

159
00:07:00,420 --> 00:06:57,130
category of elliptical galaxies called

160
00:07:02,970 --> 00:07:00,430
giant ellipticals kinda says hey they're

161
00:07:06,840 --> 00:07:02,980
kind of big as anyone ever heard of a

162
00:07:08,700 --> 00:07:06,850
category called giant spirals no

163
00:07:10,950 --> 00:07:08,710

actually we don't have a category called

164
00:07:14,850 --> 00:07:10,960
giant spirals I did see in a press

165
00:07:17,400 --> 00:07:14,860
release super spirals right but that was

166
00:07:19,500 --> 00:07:17,410
a press release nomenclature I don't

167
00:07:22,500 --> 00:07:19,510
think it's official a science

168
00:07:28,590 --> 00:07:22,510
nomenclature so our largest galaxies

169
00:07:31,940 --> 00:07:28,600
tend to be ellipticals except at the

170
00:07:35,670 --> 00:07:31,950
double-a s we released this image

171
00:07:39,630 --> 00:07:35,680
everyone say ooh and over here you guys

172
00:07:42,300 --> 00:07:39,640
say ah thank you all right this is

173
00:07:46,340 --> 00:07:42,310
Reubens galaxy our nicknamed Reubens

174
00:07:50,970 --> 00:07:46,350
galaxy it's actually called UGC 2885

175
00:07:54,480 --> 00:07:50,980
Rubin is a honor honor of Vera Rubin who

176
00:07:55,920 --> 00:07:54,490
used this galaxy to help uncover dark

177
00:07:59,850 --> 00:07:55,930
matter in the universe okay

178
00:08:02,460 --> 00:07:59,860
Vera Rubin basically looked at galaxies

179
00:08:04,800 --> 00:08:02,470
rotation and their mass and the visible

180
00:08:07,020 --> 00:08:04,810
mass and deduce that hey there's a lot

181
00:08:11,040 --> 00:08:07,030
of matter that's not emitting light it's

182
00:08:14,700 --> 00:08:11,050
we called it dark yeah all right now

183
00:08:17,100 --> 00:08:14,710
what makes this galaxies special is this

184
00:08:19,410 --> 00:08:17,110
is what would qualify as a giant spiral

185
00:08:22,110 --> 00:08:19,420
okay you can't tell by looking at it

186
00:08:25,770 --> 00:08:22,120
right because it's a spiral galaxy so I

187
00:08:28,680 --> 00:08:25,780
did a little work on in my photo editing

188
00:08:31,140 --> 00:08:28,690

program today and to a true comparison

189
00:08:33,330 --> 00:08:31,150
to the largest galaxies in the local

190
00:08:38,400 --> 00:08:33,340
group the Andromeda galaxy looks like

191
00:08:41,790 --> 00:08:38,410
that so up here this is the size of

192
00:08:45,180 --> 00:08:41,800
Andromeda alright it's around at least

193
00:08:48,240 --> 00:08:45,190
120 thousand light years across and here

194
00:08:48,540 --> 00:08:48,250
is Rubens galaxy much much bigger all

195
00:08:51,200 --> 00:08:48,550
right

196
00:08:54,630 --> 00:08:51,210
and this they called a gentle giant

197
00:08:55,200 --> 00:08:54,640
galaxy all right why would it have to be

198
00:08:58,180 --> 00:08:55,210
gentle

199
00:09:01,870 --> 00:08:58,190
all right because spiral disk

200
00:09:04,330 --> 00:09:01,880
our fragile okay if you get more than

201
00:09:07,000 --> 00:09:04,340
ten percent of the mass accreting onto

202
00:09:10,660 --> 00:09:07,010
it in an impulsive event those discs

203
00:09:13,000 --> 00:09:10,670
flop and warp and they they go all over

204
00:09:15,040 --> 00:09:13,010
the place you lose that beautiful disk

205
00:09:19,300 --> 00:09:15,050
you've got a beautiful disc still here

206
00:09:21,820 --> 00:09:19,310
so this had to inform this large at a

207
00:09:24,600 --> 00:09:21,830
spiral had to have formed in a

208
00:09:28,810 --> 00:09:24,610
relatively quiet acent way very very

209
00:09:30,010 --> 00:09:28,820
calm and cool form formation okay out in

210
00:09:33,760 --> 00:09:30,020
the middle of nowhere just slowly

211
00:09:36,700 --> 00:09:33,770
accreting stuff becoming one uh in what

212
00:09:38,950 --> 00:09:36,710
I'm told is the largest spiral galaxy in

213
00:09:41,380 --> 00:09:38,960

the nearby universe okay this is the one

214
00:09:42,400 --> 00:09:41,390
largest or the largest spiral galaxy

215
00:09:45,220 --> 00:09:42,410
that we know of

216
00:09:47,920 --> 00:09:45,230
okay it has it's about two and a half

217
00:09:50,290 --> 00:09:47,930
times larger in diameter than our Milky

218
00:09:52,900 --> 00:09:50,300
Way and the press release says it

219
00:09:55,750 --> 00:09:52,910
contains ten times as many stars as our

220
00:10:00,370 --> 00:09:55,760
galaxy so we thought our galaxy was big

221
00:10:04,510 --> 00:10:00,380
no no this is a big galaxy okay alright

222
00:10:06,010 --> 00:10:04,520
our second story is also from the double

223
00:10:07,600 --> 00:10:06,020
AAS although it wasn't a press release

224
00:10:10,000 --> 00:10:07,610
in the double yes it was just a session

225
00:10:13,530 --> 00:10:10,010
I attended at the double-a s meeting and

226
00:10:16,450 --> 00:10:13,540
it's the shape of KBO 2014 mu 69

227
00:10:20,290 --> 00:10:16,460
although actually that's wrong we no

228
00:10:22,570 --> 00:10:20,300
longer call it KBO 2014 mu 69 for the

229
00:10:24,970 --> 00:10:22,580
flyby last year they had a press release

230
00:10:30,400 --> 00:10:24,980
name and the press release name was the

231
00:10:32,290 --> 00:10:30,410
shape of Ultimo through yeah they ran a

232
00:10:35,050 --> 00:10:32,300
contest to nickname it and that was what

233
00:10:37,180 --> 00:10:35,060
they came up with Ultima Thule actually

234
00:10:41,410 --> 00:10:37,190
but they no longer call that at that

235
00:10:43,480 --> 00:10:41,420
either Ultima Thule is gone and they've

236
00:10:45,670 --> 00:10:43,490
actually given the IU has finally given

237
00:10:49,300 --> 00:10:45,680
it an official name and so the story

238
00:10:50,560 --> 00:10:49,310

really is the shape of Eric off okay

239
00:10:53,950 --> 00:10:50,570
that sounds like it's from Lord of the

240
00:10:56,140 --> 00:10:53,960
Rings doesn't it okay it's actually a

241
00:10:57,460 --> 00:10:56,150
Native American word I think I'm given

242
00:10:59,590 --> 00:10:57,470
but it does sound like a Lord of the

243
00:11:01,840 --> 00:10:59,600
Rings to me alright so what am I talking

244
00:11:05,440 --> 00:11:01,850
about I'm talking about the New Horizons

245
00:11:08,470 --> 00:11:05,450
mission okay and New Horizons originally

246
00:11:10,720 --> 00:11:08,480
went past Jupiter and then went on out

247
00:11:11,699 --> 00:11:10,730
and visited Pluto the Pluto Charon

248
00:11:13,679 --> 00:11:11,709
system okay

249
00:11:17,280 --> 00:11:13,689
and it went past the plural Karen system

250
00:11:19,040 --> 00:11:17,290
in 2015 and it was successful everything

251
00:11:20,939 --> 00:11:19,050
was working great whoops wrong button

252
00:11:22,889 --> 00:11:20,949
everything was working great so they

253
00:11:25,379 --> 00:11:22,899
said hey is there more we can do with it

254
00:11:28,410 --> 00:11:25,389
so they went out and using Hubble they

255
00:11:29,910 --> 00:11:28,420
searched and found a target for it that

256
00:11:32,460 --> 00:11:29,920
it might be able to fly be able to

257
00:11:34,169 --> 00:11:32,470
deviate the course and fly past and so

258
00:11:36,989 --> 00:11:34,179
they got an asset of fun

259
00:11:40,919 --> 00:11:36,999
the extended mission which was to fly

260
00:11:46,819 --> 00:11:40,929
past this Kuiper belt object 2014 mu 69

261
00:11:50,340 --> 00:11:46,829
ok and they did and here is the movie of

262
00:11:54,150 --> 00:11:50,350
approaching 2014 mu 69 which is now

263
00:11:56,090 --> 00:11:54,160

called era cough all right and you can't

264
00:11:59,340 --> 00:11:56,100
tell what we're approaching yet and

265
00:12:01,949 --> 00:11:59,350
you'll see as it as it starts to move to

266
00:12:08,110 --> 00:12:01,959
change there we go now you see the

267
00:12:14,679 --> 00:12:10,749
yeah this is combined from all the lorry

268
00:12:22,680 --> 00:12:14,689
images over time flying mask that Kuiper

269
00:12:29,560 --> 00:12:25,660
all right so this is the high-resolution

270
00:12:31,900 --> 00:12:29,570
image of Eric off all right and it is

271
00:12:35,410 --> 00:12:31,910
what obviously what we call a contact

272
00:12:38,370 --> 00:12:35,420
binary all right it's two ice balls that

273
00:12:42,100 --> 00:12:38,380
slowly came together and merged into one

274
00:12:49,000 --> 00:12:42,110
does anybody remember the comment rubber

275
00:12:52,570 --> 00:12:49,010
duckie comment chair mug garrison Co 6 P

276
00:12:54,430 --> 00:12:52,580
67 chairman CG anyway that was a contact

277
00:12:56,290 --> 00:12:54,440
binary okay I called it comment rubber

278
00:12:59,530 --> 00:12:56,300
duckie because it looked like a rubber

279
00:13:01,030 --> 00:12:59,540
duck okay this would be you know if it

280
00:13:03,640 --> 00:13:01,040
were a comment it'd become its Snowman

281
00:13:06,580 --> 00:13:03,650
but this is KBO snowman okay so it's

282
00:13:08,470 --> 00:13:06,590
sort of a two to Bald snowman right but

283
00:13:11,070 --> 00:13:08,480
let me actually go in a little bit more

284
00:13:14,710 --> 00:13:11,080
detail okay so here is that approach

285
00:13:15,850 --> 00:13:14,720
when you're looking at on repeat and

286
00:13:19,480 --> 00:13:15,860
you're looking at it and you know goes

287
00:13:20,830 --> 00:13:19,490
from fuzzy to clear all right and we're

288
00:13:22,960 --> 00:13:20,840

gonna watch this approach again now

289
00:13:28,030 --> 00:13:22,970
we're gonna scale it to the same size in

290
00:13:33,160 --> 00:13:30,730
got a rotating snowman like this okay

291
00:13:34,930 --> 00:13:33,170
it's rotating almost in the plane

292
00:13:39,040 --> 00:13:34,940
perpendicular to the approach vector

293
00:13:41,889 --> 00:13:39,050
that's kind of cool all right but what's

294
00:13:44,259 --> 00:13:41,899
really cool is when you look at it it's

295
00:13:47,860 --> 00:13:44,269
got an interesting shape these are not

296
00:13:50,650 --> 00:13:47,870
snow balls they're actually snow disks

297
00:13:52,300 --> 00:13:50,660
okay so this one here on the right the

298
00:13:54,790 --> 00:13:52,310
large lobe okay

299
00:13:57,100 --> 00:13:54,800
and this is the small lobe by the way in

300
00:14:01,540 --> 00:13:57,110
the small lobe this indentation here

301
00:14:03,460 --> 00:14:01,550
that's Maryland Crater okay because JHU

302
00:14:05,800 --> 00:14:03,470
Applied Physics Laboratory is where this

303
00:14:08,139 --> 00:14:05,810
is being run from and they named a named

304
00:14:11,319 --> 00:14:08,149
it Maryland Crater okay

305
00:14:13,629 --> 00:14:11,329
and so this one on the right the large

306
00:14:16,540 --> 00:14:13,639
lobe is a relatively flattened disk

307
00:14:18,910 --> 00:14:16,550
about three to one axis ratio and the

308
00:14:21,970 --> 00:14:18,920
small lobe on the left is about a two to

309
00:14:26,050 --> 00:14:21,980
one axis ratio and to see that here is

310
00:14:28,540 --> 00:14:26,060
an animation of those two lobes where

311
00:14:33,540 --> 00:14:28,550
the red arrow represents the rotation

312
00:14:36,850 --> 00:14:33,550
axis isn't this a weird looking thing

313
00:14:38,139 --> 00:14:36,860

yeah I mean first of all you get disc

314
00:14:39,850 --> 00:14:38,149
shaped things all right we're used to

315
00:14:41,620 --> 00:14:39,860
some more potato shaped things in terms

316
00:14:44,829 --> 00:14:41,630
of our asteroids in our comments on

317
00:14:47,439 --> 00:14:44,839
stuff and this is two disk shaped things

318
00:14:50,790 --> 00:14:47,449
sort of slammed together all right and

319
00:14:53,860 --> 00:14:50,800
you can see that the the structure is

320
00:14:55,420 --> 00:14:53,870
quite quite interesting and matter of

321
00:14:57,730 --> 00:14:55,430
fact you look at it you say well wait a

322
00:15:00,340 --> 00:14:57,740
minute how does two disks get together

323
00:15:03,550 --> 00:15:00,350
and spin around a central axis like that

324
00:15:04,840 --> 00:15:03,560
that's kind of weird you start puzzling

325
00:15:07,000 --> 00:15:04,850
through it and puzzling through it and

326
00:15:11,050 --> 00:15:07,010
add a session that I attended in the

327
00:15:15,309 --> 00:15:11,060
double-a s they explained some of this

328
00:15:18,220 --> 00:15:15,319
all right so here is the diagram of the

329
00:15:20,199 --> 00:15:18,230
idea of the formation of era cough so

330
00:15:22,509 --> 00:15:20,209
you have your normal formation here on

331
00:15:24,970 --> 00:15:22,519
the left okay and things are just all

332
00:15:26,740 --> 00:15:24,980
agglomerating all right and you get to

333
00:15:28,840 --> 00:15:26,750
the point where you've got this large

334
00:15:31,900 --> 00:15:28,850
object here in the center the large

335
00:15:33,939 --> 00:15:31,910
object and this more rounded object

336
00:15:37,179 --> 00:15:33,949
orbiting around each other around a

337
00:15:39,460 --> 00:15:37,189
central axis okay and then here in the

338
00:15:41,830 --> 00:15:39,470

right panel they have them co-joined

339
00:15:44,800 --> 00:15:41,840
okay that they slowly inspire

340
00:15:46,450 --> 00:15:44,810
in together and gently merge okay

341
00:15:46,960 --> 00:15:46,460
remember these are Isis okay they're not

342
00:15:49,480 --> 00:15:46,970
rocks

343
00:15:51,340 --> 00:15:49,490
these are Isis that the snake that

344
00:15:53,560 --> 00:15:51,350
you're packing to snowballs together

345
00:15:56,980 --> 00:15:53,570
okay but they're continuing to rotate

346
00:15:59,470 --> 00:15:56,990
and like our first story about that

347
00:16:01,480 --> 00:15:59,480
giant galaxy that had to live basically

348
00:16:04,270 --> 00:16:01,490
a quiet life all right

349
00:16:05,140 --> 00:16:04,280
this has to also live a very quiet life

350
00:16:08,800 --> 00:16:05,150
all right

351
00:16:11,380 --> 00:16:08,810
any major impacting strange stuff going

352
00:16:13,150 --> 00:16:11,390
on and this is not going to end up like

353
00:16:15,460 --> 00:16:13,160
this you're not gonna get this wonderful

354
00:16:19,390 --> 00:16:15,470
you know rotation around it the axis

355
00:16:23,980 --> 00:16:19,400
like that all right and so this shows

356
00:16:26,710 --> 00:16:23,990
that Eric Hoth is probable is relatively

357
00:16:29,080 --> 00:16:26,720
pristine that it hasn't had major

358
00:16:31,930 --> 00:16:29,090
impacts and such for about four and a

359
00:16:34,030 --> 00:16:31,940
half billion years okay so this stuff so

360
00:16:35,590 --> 00:16:34,040
the folks are really studying the

361
00:16:38,290 --> 00:16:35,600
surface materials and whatever they can

362
00:16:40,450 --> 00:16:38,300
glean from the flyby because this is a

363
00:16:42,790 --> 00:16:40,460

relatively pristine object from the

364
00:16:45,190 --> 00:16:42,800
early solar system if you look at all

365
00:16:47,230 --> 00:16:45,200
like the moon right it's got tons of

366
00:16:48,760 --> 00:16:47,240
things smashing it smashing into it it's

367
00:16:52,180 --> 00:16:48,770
not pristine from the early solar system

368
00:16:54,340 --> 00:16:52,190
okay this one is more pristine than any

369
00:16:55,450 --> 00:16:54,350
other object that I know of that we've

370
00:16:58,660 --> 00:16:55,460
studied that we haven't noticed close

371
00:17:00,970 --> 00:16:58,670
flyby we have a question here what is

372
00:17:02,860 --> 00:17:00,980
the size of it I should know that and

373
00:17:08,890 --> 00:17:02,870
matter fact I did know that last week I

374
00:17:10,870 --> 00:17:08,900
had it in my notes and on my iPad it's

375
00:17:13,420 --> 00:17:10,880
not tens of kilometers it's it's like

376
00:17:14,800 --> 00:17:13,430
five kilometers for the large object and

377
00:17:17,860 --> 00:17:14,810
you know three kilometers for the small

378
00:17:20,350 --> 00:17:17,870
object I can't quite remember exactly

379
00:17:22,480 --> 00:17:20,360
but it was an order of kilometers not

380
00:17:24,750 --> 00:17:22,490
tens of kilometers yes question over

381
00:17:31,570 --> 00:17:27,730
Isis yes and mostly water ice but also

382
00:17:33,030 --> 00:17:31,580
carbon dioxide ice and ammonia ice water

383
00:17:35,680 --> 00:17:33,040
carbon dioxide and ammonia are the major

384
00:17:39,610 --> 00:17:35,690
constituents easy easy to form molecules

385
00:17:41,650 --> 00:17:39,620
that you get and so yeah but you know

386
00:17:43,600 --> 00:17:41,660
it's mostly mostly water ice so it's out

387
00:17:45,790 --> 00:17:43,610
at the edge of the solar system you know

388
00:17:48,250 --> 00:17:45,800

you know it's it's it's out in the

389
00:17:50,250 --> 00:17:48,260
Kuiper belt okay beyond what's what we

390
00:17:54,580 --> 00:17:50,260
call the ice line where the ice is form

391
00:17:55,630 --> 00:17:54,590
any other questions great let's move on

392
00:17:58,660 --> 00:17:55,640
to our feature

393
00:18:10,790 --> 00:17:58,670
speaker tonight alright let's switch

394
00:18:15,520 --> 00:18:12,919
wonderful alright ladies and gentlemen

395
00:18:18,470 --> 00:18:15,530
our speaker tonight is Nimisha Kumari

396
00:18:20,030 --> 00:18:18,480
she only joined us three months ago and

397
00:18:21,799 --> 00:18:20,040
she's already giving a public lecture

398
00:18:29,030 --> 00:18:21,809
that's a really great thing from my

399
00:18:31,790 --> 00:18:29,040
point of view she actually is a heavily

400
00:18:34,190 --> 00:18:31,800
traveled astronomer having gotten her

401
00:18:36,049 --> 00:18:34,200
undergraduate degree in India her

402
00:18:40,640 --> 00:18:36,059
master's degree in France

403
00:18:42,890 --> 00:18:40,650
her PhD in England and then came here to

404
00:18:45,740 --> 00:18:42,900
the United States so she said you've

405
00:18:47,660 --> 00:18:45,750
done four countries in ten years okay so

406
00:18:49,130 --> 00:18:47,670
for an astronomer that's that's quite

407
00:19:02,150 --> 00:18:49,140
the travel astronomer ladies and you

408
00:19:04,669 --> 00:19:02,160
know Misha Kumari so hi everybody so I'm

409
00:19:06,410 --> 00:19:04,679
new Misha Kumari I'm working here at the

410
00:19:08,750 --> 00:19:06,420
Space Telescope Science Institute I

411
00:19:12,400 --> 00:19:08,760
welcome you all thank you all for coming

412
00:19:15,740 --> 00:19:12,410
I welcome especially the Astro scholars

413
00:19:20,720 --> 00:19:15,750

could you please raise your hands yeah

414
00:19:23,060 --> 00:19:20,730
so they are top students from the

415
00:19:26,360 --> 00:19:23,070
cultures and science and engineering and

416
00:19:28,730 --> 00:19:26,370
they are the future of space strana me

417
00:19:34,759 --> 00:19:28,740
so could you please give a big round of

418
00:19:42,230 --> 00:19:39,360
okay great so Cloudy with a Chance of

419
00:19:54,629 --> 00:19:46,019
have you watched this movie or read this

420
00:19:55,950 --> 00:19:54,639
book okay so so for the people who have

421
00:19:58,860 --> 00:19:55,960
I'm sorry

422
00:20:04,409 --> 00:19:58,870
actually this light is on my eye okay

423
00:20:08,060 --> 00:20:04,419
okay so for those of you who doesn't who

424
00:20:13,379 --> 00:20:08,070
don't know about this book or the movie

425
00:20:15,960 --> 00:20:13,389
briefly this in the story food form in

426
00:20:18,299 --> 00:20:15,970
the clouds in the sky and before and

427
00:20:23,369 --> 00:20:18,309
they fall from the sky okay that that is

428
00:20:26,460 --> 00:20:23,379
this story yeah that's the story but

429
00:20:28,619 --> 00:20:26,470
actually we don't I I don't know I I

430
00:20:31,230 --> 00:20:28,629
don't know any story about food forming

431
00:20:33,899 --> 00:20:31,240
like the real story I mean I don't know

432
00:20:36,629 --> 00:20:33,909
any of those stories where food form and

433
00:20:39,539 --> 00:20:36,639
clouds and fall from the sky but we do

434
00:20:42,779 --> 00:20:39,549
have evidence of stars forming and gas

435
00:20:45,629 --> 00:20:42,789
clouds so that's why the title of my

436
00:20:51,450 --> 00:20:45,639
talk is Cloudy with a Chance of not

437
00:20:58,350 --> 00:20:51,460
meatballs but stars okay so where do we

438
00:21:00,749 --> 00:20:58,360

see stars space sky yeah and exactly

439
00:21:04,769 --> 00:21:00,759
where in sky where are they located

440
00:21:07,169 --> 00:21:04,779
where are the stars everywhere actually

441
00:21:09,419 --> 00:21:07,179
what you see here like when you see in

442
00:21:10,919 --> 00:21:09,429
the sky does whatever starts you are

443
00:21:13,519 --> 00:21:10,929
seeing there they are in the Milky Way

444
00:21:21,029 --> 00:21:13,529
that is our galaxy so stars are actually

445
00:21:24,600 --> 00:21:21,039
found in galaxies okay and what are

446
00:21:30,269 --> 00:21:24,610
galaxies so galaxies are composed of

447
00:21:33,930 --> 00:21:30,279
stars and gas dust and they are held

448
00:21:38,909 --> 00:21:33,940
together by the force of gravitational

449
00:21:42,359 --> 00:21:38,919
attraction okay so this figure here this

450
00:21:46,590 --> 00:21:42,369
image is taken by Hubble Space Telescope

451
00:21:47,580 --> 00:21:46,600
over a period of six months this whole

452
00:21:51,239 --> 00:21:47,590
strip

453
00:21:53,909 --> 00:21:51,249
is the image is around it's actually

454
00:21:56,399 --> 00:21:53,919
less than one millimeter by one

455
00:21:59,789 --> 00:21:56,409
millimeter piece of paper held at a

456
00:22:03,480 --> 00:21:59,799
distance of one meter away okay and in

457
00:22:06,060 --> 00:22:03,490
this small strip actually it's actually

458
00:22:10,259 --> 00:22:06,070
a 113th millionth of the total area of

459
00:22:13,919 --> 00:22:10,269
the sky and there you see around ten

460
00:22:16,350 --> 00:22:13,929
thousand galaxies okay so I really find

461
00:22:18,539 --> 00:22:16,360
it very amazing that in such a small

462
00:22:22,470 --> 00:22:18,549
area of sky you can see ten thousand

463
00:22:27,510 --> 00:22:25,080

now actually frank already mentioned

464
00:22:28,380 --> 00:22:27,520
this there are various types of galaxies

465
00:22:30,900 --> 00:22:28,390
okay

466
00:22:33,120 --> 00:22:30,910
there are morphologically different

467
00:22:35,580 --> 00:22:33,130
their physical properties their chemical

468
00:22:40,620 --> 00:22:35,590
properties they are different and here

469
00:22:42,690 --> 00:22:40,630
on this diagram actually it is a way to

470
00:22:46,470 --> 00:22:42,700
classify different types of galaxies

471
00:22:49,350 --> 00:22:46,480
this was devised by Edwin Hubble in

472
00:22:54,690 --> 00:22:49,360
whose honor we have Hubble Space

473
00:23:00,300 --> 00:22:54,700
Telescope and in this diagram different

474
00:23:03,870 --> 00:23:00,310
galaxies are located on the handle and

475
00:23:06,420 --> 00:23:03,880
on the bars of the tuning fork okay

476
00:23:08,520 --> 00:23:06,430
there are elliptical galaxies which are

477
00:23:11,250 --> 00:23:08,530
on the handle they are like massive

478
00:23:14,070 --> 00:23:11,260
elliptical their their shapes are

479
00:23:15,840 --> 00:23:14,080
elliptical and there are spiral galaxies

480
00:23:17,880 --> 00:23:15,850
where you can see spirals some of them

481
00:23:21,540 --> 00:23:17,890
have got bars in them and some of them

482
00:23:22,950 --> 00:23:21,550
they don't have bars and there are some

483
00:23:24,600 --> 00:23:22,960
galaxies which are in turbot

484
00:23:27,170 --> 00:23:24,610
intermediate between the bar and

485
00:23:30,810 --> 00:23:27,180
unbarred galaxies which are kind of

486
00:23:33,420 --> 00:23:30,820
represented here and then there are some

487
00:23:36,230 --> 00:23:33,430
other types of galaxies which are which

488
00:23:40,710 --> 00:23:36,240

which are irregular they don't have any

489
00:23:43,500 --> 00:23:40,720
proper size not sighs I mean shape

490
00:23:47,640 --> 00:23:43,510
actually they do have size proper size

491
00:23:49,530 --> 00:23:47,650
but yes I mean so these irregular

492
00:23:52,140 --> 00:23:49,540
galaxies they are neither electrical

493
00:23:55,590 --> 00:23:52,150
they are neither and they are not like

494
00:23:57,210 --> 00:23:55,600
spirals with arms they don't they can

495
00:23:59,490 --> 00:23:57,220
have bars they don't it's not

496
00:24:02,760 --> 00:23:59,500
necessarily that they have bars so these

497
00:24:07,500 --> 00:24:02,770
are irregular galaxies so if you go on

498
00:24:10,200 --> 00:24:07,510
this link then you will find this

499
00:24:12,390 --> 00:24:10,210
picture and if you click on each of

500
00:24:13,860 --> 00:24:12,400
these boxes then you can get information

501
00:24:16,670 --> 00:24:13,870
about each of those galaxies so I

502
00:24:20,190 --> 00:24:16,680
encourage you to go on that link and

503
00:24:22,710 --> 00:24:20,200
explore these galaxies now this is the

504
00:24:25,530 --> 00:24:22,720
zoomed in view of some of the spiral

505
00:24:27,810 --> 00:24:25,540
galaxies spiral galaxies are the most

506
00:24:30,980 --> 00:24:27,820
abundant in the nearby universe for

507
00:24:35,120 --> 00:24:30,990
example the Milky Way is a spiral galaxy

508
00:24:36,600 --> 00:24:35,130
and here are some of the examples of

509
00:24:38,820 --> 00:24:36,610
dwarf

510
00:24:41,039 --> 00:24:38,830
is the those actually they are blue

511
00:24:43,140 --> 00:24:41,049
compact or galaxies they are the special

512
00:24:44,960 --> 00:24:43,150
class of torch galaxies and that those

513
00:24:49,070 --> 00:24:44,970

galaxies is fall in the category of

514
00:24:52,950 --> 00:24:49,080
irregular galaxies we don't have any

515
00:24:56,910 --> 00:24:52,960
particular shape like ellipticals or

516
00:24:59,190 --> 00:24:56,920
spirals and these galaxies are actually

517
00:25:00,900 --> 00:24:59,200
very tiny compared to the spiral

518
00:25:03,810 --> 00:25:00,910
galaxies for example I have worked on

519
00:25:08,760 --> 00:25:03,820
dwarf galaxies which are about 10% the

520
00:25:11,370 --> 00:25:08,770
size of our Milky Way now

521
00:25:16,250 --> 00:25:11,380
home sweet home the Milky Way you might

522
00:25:19,650 --> 00:25:16,260
identify this picture actually this belt

523
00:25:22,020 --> 00:25:19,660
is that of the Milky Way actually and

524
00:25:24,539 --> 00:25:22,030
that was taken from South Pacific

525
00:25:25,140 --> 00:25:24,549
paradise of manga a suddenly of Cook

526
00:25:29,250 --> 00:25:25,150
Islands

527
00:25:31,830 --> 00:25:29,260
so this is our Milky Way and these dark

528
00:25:33,200 --> 00:25:31,840
patches they are actually dusty regions

529
00:25:38,880 --> 00:25:33,210
within our galaxy

530
00:25:41,640 --> 00:25:38,890
and here are images of our own galaxy

531
00:25:44,280 --> 00:25:41,650
the Milky Way taken a different

532
00:25:47,100 --> 00:25:44,290
wavelength bands so radio continuum

533
00:25:51,470 --> 00:25:47,110
atomic hydrogen so that is the

534
00:25:55,620 --> 00:25:51,480
wavelength bands go from for example

535
00:25:58,560 --> 00:25:55,630
from radio waves to gamma rays and each

536
00:26:02,070 --> 00:25:58,570
of these wavelength bands are probing a

537
00:26:05,100 --> 00:26:02,080
particular property of the galaxy for

538
00:26:08,580 --> 00:26:05,110

example this this one the second strip

539
00:26:12,210 --> 00:26:08,590
here which you see that it that image is

540
00:26:14,220 --> 00:26:12,220
taken in radio and this image is

541
00:26:17,100 --> 00:26:14,230
actually telling you about the atomic

542
00:26:19,590 --> 00:26:17,110
gas content of the Milky Way now if we

543
00:26:21,810 --> 00:26:19,600
come here infrared is glowing very

544
00:26:24,960 --> 00:26:21,820
brightly in the center and that is

545
00:26:28,590 --> 00:26:24,970
actually tracing the dest content of the

546
00:26:31,760 --> 00:26:28,600
Milky Way and for example the optical to

547
00:26:35,100 --> 00:26:31,770
which our eyes are such susceptible

548
00:26:37,799 --> 00:26:35,110
what we see mostly here is dark actually

549
00:26:39,870 --> 00:26:37,809
there is so much of dust so the optical

550
00:26:45,090 --> 00:26:39,880
light is actually absorbed by all the

551
00:26:49,530 --> 00:26:45,100
dusty regions in our Milky Way ok so by

552
00:26:50,350 --> 00:26:49,540
looking at an object or a source in

553
00:26:52,510 --> 00:26:50,360
different

554
00:26:56,460 --> 00:26:52,520
Waveland bands were actually looking at

555
00:27:01,270 --> 00:26:56,470
different properties of that system okay

556
00:27:16,890 --> 00:27:01,280
now let's look at a zoo min view of our

557
00:28:02,620 --> 00:27:58,799
[Music]

558
00:28:06,030 --> 00:28:02,630
okay so what we saw there was we zoomed

559
00:28:09,250 --> 00:28:06,040
into our Milky Way and then we went into

560
00:28:10,840 --> 00:28:09,260
the constellation of Orion and actually

561
00:28:14,680 --> 00:28:10,850
that is my favorite constellation

562
00:28:16,659 --> 00:28:14,690
because it looks like hunter oops I'm

563
00:28:19,990 --> 00:28:16,669

sorry and I really like this

564
00:28:22,690 --> 00:28:20,000
constellation for some reason these

565
00:28:24,970 --> 00:28:22,700
three stars button to Yousef and Rygel

566
00:28:28,480 --> 00:28:24,980
they are the three prominent stars in in

567
00:28:30,700 --> 00:28:28,490
this constellation and then in the

568
00:28:33,430 --> 00:28:30,710
center here as well on the belt of Orion

569
00:28:36,820 --> 00:28:33,440
there they're again three stars if we go

570
00:28:39,669 --> 00:28:36,830
down the belt on the sword there is this

571
00:28:42,039 --> 00:28:39,679
Orion Nebula you might have heard about

572
00:28:45,610 --> 00:28:42,049
Orion Nebula this is actually one of the

573
00:28:49,600 --> 00:28:45,620
brightest star forming region and which

574
00:28:52,060 --> 00:28:49,610
is visible to the naked eye so if we

575
00:28:55,060 --> 00:28:52,070
zoom into the Orion Nebula this is an

576
00:28:58,930 --> 00:28:55,070
image which consists of about billion

577
00:29:02,409 --> 00:28:58,940
pixels and it contains about 3,000 stars

578
00:29:05,320 --> 00:29:02,419
so this is around 24 years 24 light

579
00:29:07,390 --> 00:29:05,330
years across and it is fifteen hundred

580
00:29:12,520 --> 00:29:07,400
light years away but still it isn't it

581
00:29:15,100 --> 00:29:12,530
it is visible to the naked eye so let's

582
00:29:22,930 --> 00:29:15,110
see that video again to understand what

583
00:29:22,940 --> 00:29:31,000
you

584
00:30:15,169 --> 00:29:38,380
[Music]

585
00:30:20,669 --> 00:30:18,690
so or I nebula is a star-forming region

586
00:30:22,230 --> 00:30:20,679
okay and like Orion Nebula

587
00:30:24,600 --> 00:30:22,240
there are several star forming regions

588
00:30:28,140 --> 00:30:24,610

in our galaxy and also in the outer

589
00:30:33,270 --> 00:30:28,150
galaxies so Rossiter nebula is one of

590
00:30:36,840 --> 00:30:33,280
such one of such star forming regions so

591
00:30:38,970 --> 00:30:36,850
but I'm speaking of star forming regions

592
00:30:41,970 --> 00:30:38,980
I mentioned nebula so why does maybe

593
00:30:46,190 --> 00:30:41,980
like up here all the time in the name of

594
00:30:51,810 --> 00:30:46,200
star forming regions can someone guess

595
00:31:00,320 --> 00:30:51,820
sorry so nebula does someone speak

596
00:31:04,110 --> 00:31:00,330
Spanish nebula means cloud yeah yeah

597
00:31:06,540 --> 00:31:04,120
yeah yeah so nebula means clouds and

598
00:31:08,460 --> 00:31:06,550
since stars form in gas clouds

599
00:31:13,040 --> 00:31:08,470
that's why star forming regions are

600
00:31:15,570 --> 00:31:13,050
often called nebulas okay and this

601
00:31:16,890 --> 00:31:15,580
rosette nebula can you guess why tis

602
00:31:20,370 --> 00:31:16,900
called Rosetta nebula

603
00:31:23,250 --> 00:31:20,380
it looks like rose okay and the petals

604
00:31:25,500 --> 00:31:23,260
of the rose actually these are these are

605
00:31:27,690 --> 00:31:25,510
where these are the reasons where the

606
00:31:29,400 --> 00:31:27,700
stars are forming so this was a

607
00:31:32,700 --> 00:31:29,410
challenge Allah is hundred light years

608
00:31:34,740 --> 00:31:32,710
across so it is larger than the Orion

609
00:31:36,570 --> 00:31:34,750
Nebula and it's five thousand light

610
00:31:39,840 --> 00:31:36,580
years away so it's farther than the

611
00:31:41,760 --> 00:31:39,850
Orion Nebula so the question is how do

612
00:31:44,640 --> 00:31:41,770
stars form let's get to that point

613
00:31:50,190 --> 00:31:44,650

so what strong astronomy students are

614
00:31:56,600 --> 00:31:50,200
taught in school well in grad school

615
00:32:00,410 --> 00:31:56,610
maybe so what they are taught is that

616
00:32:06,480 --> 00:32:00,420
stars are formed in giant interstellar

617
00:32:08,970 --> 00:32:06,490
clouds of gas okay so to demonstrate

618
00:32:16,160 --> 00:32:08,980
that actually what happens how stars

619
00:32:19,810 --> 00:32:16,170
form let us assume that oops

620
00:32:28,220 --> 00:32:19,820
air is coming out actually so I need to

621
00:32:31,640 --> 00:32:28,230
okay so let us assume that that this is

622
00:32:35,419 --> 00:32:31,650
a star-forming region okay so there is

623
00:32:38,240 --> 00:32:35,429
gas inside it which is holding this

624
00:32:40,880 --> 00:32:38,250
balloon so that is like a star-forming

625
00:32:44,030 --> 00:32:40,890
region actually there is gas inside is

626
00:32:45,830 --> 00:32:44,040
there is grass gas pressure and after

627
00:32:47,930 --> 00:32:45,840
that there is this gravitational

628
00:32:49,970 --> 00:32:47,940
attraction around it and the

629
00:32:53,540 --> 00:32:49,980
star-forming region what happens for

630
00:32:57,910 --> 00:32:53,550
example in this balloon is that if you

631
00:33:05,090 --> 00:32:57,920
if I go on pumping air what will happen

632
00:33:13,669 --> 00:33:05,100
well let me try to if I go on pumping

633
00:33:16,250 --> 00:33:13,679
air let's assume that I that I pumped a

634
00:33:18,230 --> 00:33:16,260
lot of air inside and what will happen

635
00:33:19,040 --> 00:33:18,240
what will happen is that it will burst

636
00:33:23,360 --> 00:33:19,050
okay

637
00:33:25,940 --> 00:33:23,370
however if the gas pressure is not that

638
00:33:28,790 --> 00:33:25,950

high what will happen it will collapse

639
00:33:32,210 --> 00:33:28,800
that happened very quickly okay so the

640
00:33:34,669 --> 00:33:32,220
same thing the same scenario is forests

641
00:33:36,320 --> 00:33:34,679
are forming region as well there is a

642
00:33:38,299 --> 00:33:36,330
star-forming region there is gas

643
00:33:42,290 --> 00:33:38,309
pressure inside it and there is this

644
00:33:46,010 --> 00:33:42,300
gravitational attraction from the outer

645
00:33:47,780 --> 00:33:46,020
part if it is a gas cloud like it's in

646
00:33:50,450 --> 00:33:47,790
the very simple picture of gas cloud and

647
00:33:53,090 --> 00:33:50,460
if the gas pressure is very high then

648
00:33:55,100 --> 00:33:53,100
everything will be blown away however if

649
00:33:59,510 --> 00:33:55,110
the gravitational attraction is higher

650
00:34:02,210 --> 00:33:59,520
than the gas pressure then the gas will

651
00:34:06,080 --> 00:34:02,220
collapse and that will lead to the

652
00:34:11,359 --> 00:34:06,090
formation of stars but that will happen

653
00:34:14,869 --> 00:34:11,369
only for a mass of for a cloud gas cloud

654
00:34:17,480 --> 00:34:14,879
of mass of a particular which is above a

655
00:34:21,080 --> 00:34:17,490
particular mass that that is called

656
00:34:22,849 --> 00:34:21,090
jeans mass it's because it was devised

657
00:34:24,109 --> 00:34:22,859
by James jeans he was a British

658
00:34:28,010 --> 00:34:24,119
astrophysicist

659
00:34:29,840 --> 00:34:28,020
so for estimating that mass there are

660
00:34:31,849 --> 00:34:29,850
two parameters which become very

661
00:34:33,590 --> 00:34:31,859
important those are density and

662
00:34:35,210 --> 00:34:33,600
temperature so

663
00:34:38,480 --> 00:34:35,220

the temperature should be very low and

664
00:34:42,140 --> 00:34:38,490
the density should be very high for the

665
00:34:44,780 --> 00:34:42,150
cloud collapse to take place okay so

666
00:34:48,080 --> 00:34:44,790
here are the subsequent steps of star

667
00:34:50,390 --> 00:34:48,090
formation what happens is that in gas

668
00:34:57,520 --> 00:34:50,400
cloud different regions have different

669
00:35:00,760 --> 00:34:57,530
densities so when the so when the

670
00:35:04,040 --> 00:35:00,770
gravitation dominates

671
00:35:05,870 --> 00:35:04,050
regions of high density becomes even

672
00:35:08,180 --> 00:35:05,880
more denser which leads to the

673
00:35:11,060 --> 00:35:08,190
fragmentation of gas clouds which lead

674
00:35:15,200 --> 00:35:11,070
to the forms which lead to the formation

675
00:35:19,100 --> 00:35:15,210
of course and biddin those course stars

676
00:35:21,560 --> 00:35:19,110
form within each code there can be stir

677
00:35:24,140 --> 00:35:21,570
and there can be a single star by binary

678
00:35:27,380 --> 00:35:24,150
star or there can be multiple stars and

679
00:35:30,200 --> 00:35:27,390
those stars have they can be very

680
00:35:34,550 --> 00:35:30,210
different like you might know like there

681
00:35:38,240 --> 00:35:34,560
was a there was a lecture in December

682
00:35:40,340 --> 00:35:38,250
here where my colleague talked about

683
00:35:43,180 --> 00:35:40,350
different types of stars but that is for

684
00:35:46,340 --> 00:35:43,190
another lecture so the thing is

685
00:35:47,780 --> 00:35:46,350
fragmentation happens which lead to the

686
00:35:51,740 --> 00:35:47,790
formation of course and within those

687
00:35:53,450 --> 00:35:51,750
course stars form and then here for

688
00:35:55,820 --> 00:35:53,460

example again there is this receipt and

689
00:35:58,640 --> 00:35:55,830
a beloved where you already see those

690
00:36:02,750 --> 00:35:58,650
stars forming or the stars which have

691
00:36:06,230 --> 00:36:02,760
already formed so now you would say ok

692
00:36:08,330 --> 00:36:06,240
we know how stars form actually we know

693
00:36:10,190 --> 00:36:08,340
that that is gravitation which is very

694
00:36:13,040 --> 00:36:10,200
important for the formation of stars is

695
00:36:15,290 --> 00:36:13,050
the gas cloud which where the stars form

696
00:36:18,140 --> 00:36:15,300
so what is it which we don't know what

697
00:36:20,150 --> 00:36:18,150
are we working on why are scientists

698
00:36:22,190 --> 00:36:20,160
working on star formation so the thing

699
00:36:24,560 --> 00:36:22,200
is there are many many things which we

700
00:36:27,050 --> 00:36:24,570
don't know for example we don't know how

701
00:36:29,480 --> 00:36:27,060
gas clouds are formed then we don't know

702
00:36:32,720 --> 00:36:29,490
what type of gas is actually responsible

703
00:36:35,870 --> 00:36:32,730
for the formation of stars and then the

704
00:36:39,620 --> 00:36:35,880
critical process what is the main driver

705
00:36:43,820 --> 00:36:39,630
for the formation of stars if that

706
00:36:46,220 --> 00:36:43,830
process is local or if it is global by

707
00:36:47,330 --> 00:36:46,230
local I mean if it is just a star

708
00:36:49,250 --> 00:36:47,340
forming region which is

709
00:36:52,160 --> 00:36:49,260
patent or if it is a global process I

710
00:36:53,900 --> 00:36:52,170
mean where the whole galaxy the

711
00:36:57,020 --> 00:36:53,910
movements in the whole galaxy leads to

712
00:36:58,880 --> 00:36:57,030
the leads to the formation of gas clouds

713
00:37:01,760 --> 00:36:58,890

which lead to the formation of stars if

714
00:37:03,800 --> 00:37:01,770
it is a sub if it is a step-by-step

715
00:37:05,750 --> 00:37:03,810
process or everything is happening at

716
00:37:08,720 --> 00:37:05,760
the same time so it's a very complicated

717
00:37:10,700 --> 00:37:08,730
thing we don't know a lot of things but

718
00:37:13,310 --> 00:37:10,710
in summary what I'm trying to say is

719
00:37:15,230 --> 00:37:13,320
that there is no predictive theory even

720
00:37:18,320 --> 00:37:15,240
though we know that stars formed from

721
00:37:21,110 --> 00:37:18,330
gas we don't know if for example I have

722
00:37:23,420 --> 00:37:21,120
a certain amount of gas how many stars I

723
00:37:29,030 --> 00:37:23,430
was formed that is a question we don't

724
00:37:35,090 --> 00:37:29,040
know how to do that so you might have

725
00:37:39,290 --> 00:37:35,100
heard of Fred company now okay he's the

726
00:37:41,630 --> 00:37:39,300
guy here in the center Fred Kelly was

727
00:37:45,140 --> 00:37:41,640
the founder of couply foundation and

728
00:37:47,900 --> 00:37:45,150
Carly Foundation awards public prizes

729
00:37:50,800 --> 00:37:47,910
every two years the first cubby prize in

730
00:37:53,990 --> 00:37:50,810
astrophysics was given to these two

731
00:37:59,570 --> 00:37:54,000
astronomers Martin Smith and Donna

732
00:38:02,570 --> 00:37:59,580
Lyndonville their work was on quasars

733
00:38:05,450 --> 00:38:02,580
which was rewarded for during the skully

734
00:38:08,690 --> 00:38:05,460
prize however like most of the

735
00:38:10,940 --> 00:38:08,700
astronomers they didn't only work on

736
00:38:13,730 --> 00:38:10,950
quizzes they worked on many different

737
00:38:18,680 --> 00:38:13,740
things for example martin smith he

738
00:38:24,880 --> 00:38:18,690

worked on star formation so let's go

739
00:38:28,310 --> 00:38:24,890
back to 1959 in 1959 martin smith gave a

740
00:38:31,990 --> 00:38:28,320
relation between the volume densities of

741
00:38:35,090 --> 00:38:32,000
star formation rate and gas however

742
00:38:40,450 --> 00:38:35,100
measuring volume density is a very

743
00:38:51,920 --> 00:38:48,980
because when strongman's take data they

744
00:38:54,530 --> 00:38:51,930
are like they are actually images they

745
00:38:56,840 --> 00:38:54,540
are two-dimensional surfaces to estimate

746
00:39:00,280 --> 00:38:56,850
volume densities we need a higher

747
00:39:01,750 --> 00:39:00,290
dimension okay so since we don't

748
00:39:04,270 --> 00:39:01,760
third dimension it becomes very

749
00:39:07,150 --> 00:39:04,280
difficult to measure the volume density

750
00:39:11,680 --> 00:39:07,160
when we are doing any analysis with the

751
00:39:14,470 --> 00:39:11,690
data so Martin Smith was very smart

752
00:39:17,170 --> 00:39:14,480
he simply simplified everything he

753
00:39:21,700 --> 00:39:17,180
changed volume density to surface

754
00:39:24,130 --> 00:39:21,710
density so that was his relation this is

755
00:39:27,040 --> 00:39:24,140
on the left hand side you have star

756
00:39:29,620 --> 00:39:27,050
formation rate surface density and on

757
00:39:32,220 --> 00:39:29,630
the right hand side you have the surface

758
00:39:34,780 --> 00:39:32,230
density of gas and here you see this n

759
00:39:37,810 --> 00:39:34,790
raised to the power N and because of

760
00:39:40,660 --> 00:39:37,820
this power n this relation is called

761
00:39:42,820 --> 00:39:40,670
power law and many astronomers and

762
00:39:49,210 --> 00:39:42,830
around the world they are working to

763
00:39:54,310 --> 00:39:49,220

find out what's the value of n okay so

764
00:39:57,070 --> 00:39:54,320
at least here by looking at these at

765
00:40:00,340 --> 00:39:57,080
this equation we know that there are two

766
00:40:03,040 --> 00:40:00,350
quantities which are very important star

767
00:40:06,130 --> 00:40:03,050
formation rate and gas and we need to

768
00:40:08,370 --> 00:40:06,140
measure these two things before we infer

769
00:40:12,190 --> 00:40:08,380
anything about the star formation rate

770
00:40:15,250 --> 00:40:12,200
okay so the first thing is how do we

771
00:40:17,650 --> 00:40:15,260
measure star formation rate and gas

772
00:40:19,840 --> 00:40:17,660
content because once we are able to

773
00:40:21,910 --> 00:40:19,850
measure the star formation rate and gas

774
00:40:24,310 --> 00:40:21,920
then it is very easy to measure the

775
00:40:27,910 --> 00:40:24,320
density because then you just have to

776
00:40:31,720 --> 00:40:27,920
divide that star formation rate or gas

777
00:40:33,370 --> 00:40:31,730
with the area of that region okay and

778
00:40:37,150 --> 00:40:33,380
that will give you the surface and the

779
00:40:39,340 --> 00:40:37,160
surface density so how do we measure the

780
00:40:41,770 --> 00:40:39,350
star formation rate so there are several

781
00:40:45,550 --> 00:40:41,780
ways to measure risk but I'm going to

782
00:40:47,440 --> 00:40:45,560
and it is a very active area of research

783
00:40:51,820 --> 00:40:47,450
in itself I'm going to give a very

784
00:40:56,830 --> 00:40:51,830
simplified picture here when we observe

785
00:41:00,760 --> 00:40:56,840
anything any source any star forming

786
00:41:03,070 --> 00:41:00,770
region any galaxy then we do it at a

787
00:41:07,540 --> 00:41:03,080
particular wavelength that can be

788
00:41:12,580 --> 00:41:07,550

optical infrared radio like the like the

789
00:41:13,860 --> 00:41:12,590
images I showed you earlier and why we

790
00:41:16,440 --> 00:41:13,870
observe in different

791
00:41:19,140 --> 00:41:16,450
and bands is because when we observe at

792
00:41:21,540 --> 00:41:19,150
a particular band then at a particular

793
00:41:24,120 --> 00:41:21,550
wavelength then we are probing a certain

794
00:41:27,120 --> 00:41:24,130
property of that region so we take

795
00:41:28,890 --> 00:41:27,130
images for example for example this one

796
00:41:30,990 --> 00:41:28,900
is the Orion Nebula in the Milky Way

797
00:41:35,130 --> 00:41:31,000
which I already showed you earlier and

798
00:41:37,710 --> 00:41:35,140
this one is the Whirlpool Galaxy you

799
00:41:41,940 --> 00:41:37,720
might already know that these pink

800
00:41:44,580 --> 00:41:41,950
regions on the spiral arm of Whirlpool

801
00:41:49,620 --> 00:41:44,590
Galaxy they are actually the star

802
00:41:58,760 --> 00:41:49,630
forming regions and these dark patches

803
00:42:05,820 --> 00:41:58,770
here those are Gina tests yes those are

804
00:42:07,830 --> 00:42:05,830
dusty regions so if we want to

805
00:42:10,350 --> 00:42:07,840
understand what a star-forming region

806
00:42:12,390 --> 00:42:10,360
looks like or how we want to measure the

807
00:42:14,340 --> 00:42:12,400
star formation rate we first need to

808
00:42:16,620 --> 00:42:14,350
understand how star forming region looks

809
00:42:20,760 --> 00:42:16,630
like what wavelengths we can use to

810
00:42:23,880 --> 00:42:20,770
study that region so let's have a look

811
00:42:26,480 --> 00:42:23,890
at a typical star forming region in a

812
00:42:30,360 --> 00:42:26,490
typical star forming region there are

813
00:42:33,450 --> 00:42:30,370

stars which emit and they're hot and

814
00:42:37,920 --> 00:42:33,460
massive stars and they emit mostly in

815
00:42:40,500 --> 00:42:37,930
ultraviolet the that ultraviolet

816
00:42:44,880 --> 00:42:40,510
radiation ionize the gas around them

817
00:42:49,260 --> 00:42:44,890
around the stars and that ionized gas

818
00:42:53,070 --> 00:42:49,270
emission optical so from the simple

819
00:42:55,770 --> 00:42:53,080
picture of a typical star forming region

820
00:42:58,860 --> 00:42:55,780
there are two wavelength bands we know

821
00:43:01,260 --> 00:42:58,870
would be useful to probe a star-forming

822
00:43:04,850 --> 00:43:01,270
region and to understand what is the

823
00:43:12,020 --> 00:43:04,860
star formation rate so those bands are

824
00:43:15,660 --> 00:43:12,030
ultraviolet and optical ok now beside

825
00:43:19,540 --> 00:43:15,670
stars and gas what do you think is

826
00:43:31,660 --> 00:43:28,090
dust dust so this again I'm showing you

827
00:43:34,540 --> 00:43:31,670
how prominent test is for example here

828
00:43:39,610 --> 00:43:34,550
is the Triffids a Beulah and you know

829
00:43:46,020 --> 00:43:39,620
why it's called tri fit because there

830
00:43:50,020 --> 00:43:46,030
are these three lanes of dust and this

831
00:43:53,440 --> 00:43:50,030
trifle nebula is actually illuminated by

832
00:43:55,570 --> 00:43:53,450
one single massive star here and this

833
00:43:56,920 --> 00:43:55,580
and this is the dusty Lea and that's why

834
00:43:58,810 --> 00:43:56,930
it's called trifle nebula it's all

835
00:44:00,910 --> 00:43:58,820
because of the dust that it's it gets

836
00:44:04,450 --> 00:44:00,920
its name and then after that there is

837
00:44:06,430 --> 00:44:04,460
this galaxy NGC 891 I particularly I

838
00:44:09,130 --> 00:44:06,440

have put this galaxy particularly here

839
00:44:11,470 --> 00:44:09,140
because it's very interesting it's an

840
00:44:13,540 --> 00:44:11,480
edge-on galaxy so either you can see a

841
00:44:16,720 --> 00:44:13,550
galaxy like this or it's like a

842
00:44:19,200 --> 00:44:16,730
different orientation okay here we are

843
00:44:22,180 --> 00:44:19,210
seeing an h1 galaxy and here

844
00:44:26,320 --> 00:44:22,190
perpendicular to this disk of the galaxy

845
00:44:32,110 --> 00:44:26,330
you can see the dust lanes so jess is

846
00:44:33,850 --> 00:44:32,120
actually a big problem so when we

847
00:44:35,470 --> 00:44:33,860
measure star formation rate the first

848
00:44:40,180 --> 00:44:35,480
problem is dust

849
00:44:43,960 --> 00:44:40,190
what does just is it absorbs the optical

850
00:44:47,080 --> 00:44:43,970
light or the ultraviolet light and when

851
00:44:50,230 --> 00:44:47,090
we are measuring or when we are

852
00:44:53,110 --> 00:44:50,240
observing a star formulation or a galaxy

853
00:44:55,360 --> 00:44:53,120
in optical or ultraviolet light then we

854
00:44:57,580 --> 00:44:55,370
are not actually measuring all light

855
00:45:00,430 --> 00:44:57,590
which is emitted by the star or from the

856
00:45:04,330 --> 00:45:00,440
ionized gas because some of it is

857
00:45:07,990 --> 00:45:04,340
obscured by the dust so what we need to

858
00:45:12,940 --> 00:45:08,000
do is observe this star forming region

859
00:45:14,700 --> 00:45:12,950
in on a wave at a wavelength which can

860
00:45:18,790 --> 00:45:14,710
actually trace the light which is

861
00:45:20,950 --> 00:45:18,800
obscured by the dust and do you know

862
00:45:26,260 --> 00:45:20,960
which wavelength band would be useful

863
00:45:29,560 --> 00:45:26,270

for that infrared yeah so infrared is

864
00:45:32,549 --> 00:45:29,570
useful for tracing in their presence of

865
00:45:37,480 --> 00:45:32,559
just in a star-forming region

866
00:45:43,210 --> 00:45:37,490
now let's come to the second problem so

867
00:45:45,279 --> 00:45:43,220
this second problem people the people

868
00:45:46,960 --> 00:45:45,289
who are working on star formation not

869
00:45:48,789 --> 00:45:46,970
everybody is very much concerned about

870
00:45:52,510 --> 00:45:48,799
this problem but actually it is a

871
00:45:56,440 --> 00:45:52,520
problem I will explain it to you in a

872
00:45:58,180 --> 00:45:56,450
bit so for example when we measure when

873
00:46:00,640 --> 00:45:58,190
we have to measure the star formation

874
00:46:05,680 --> 00:46:00,650
rate it's like measuring the birth rate

875
00:46:09,130 --> 00:46:05,690
of the world or the birth rate at a

876
00:46:11,170 --> 00:46:09,140
region at a place in the world so when

877
00:46:14,380 --> 00:46:11,180
we are measuring the birth rate we have

878
00:46:17,250 --> 00:46:14,390
to count the number of children who are

879
00:46:22,990 --> 00:46:17,260
born like the younger generation okay

880
00:46:24,940 --> 00:46:23,000
that's how you get battery but in the

881
00:46:27,430 --> 00:46:24,950
world or in a place they are not only

882
00:46:31,990 --> 00:46:27,440
children there are older people as well

883
00:46:38,230 --> 00:46:32,000
so to understand the birth rate you have

884
00:46:40,960 --> 00:46:38,240
to separate the babies from the older

885
00:46:42,910 --> 00:46:40,970
people and that's the same case with a

886
00:46:45,819 --> 00:46:42,920
typical star forming region there are

887
00:46:50,950 --> 00:46:45,829
not only young stars but there are also

888
00:46:54,069 --> 00:46:50,960

older stars so we need to separate the

889
00:46:57,130 --> 00:46:54,079
light okay I will say we need to

890
00:47:01,539 --> 00:46:57,140
separate the young stars from the old

891
00:47:04,089 --> 00:47:01,549
stars and then that will be sub and then

892
00:47:07,299 --> 00:47:04,099
that will correspond to separating the

893
00:47:10,599 --> 00:47:07,309
light which was emitted by the younger

894
00:47:12,490 --> 00:47:10,609
stars and the older stars now in a star

895
00:47:17,529 --> 00:47:12,500
forming region you have stars and you

896
00:47:24,190 --> 00:47:17,539
also have just now just greens can also

897
00:47:27,430 --> 00:47:24,200
be old and young they can be hot and

898
00:47:30,880 --> 00:47:27,440
cold so they have different properties

899
00:47:33,940 --> 00:47:30,890
as well so they not know not all the

900
00:47:36,940 --> 00:47:33,950
dust grains correspond to the current

901
00:47:39,910 --> 00:47:36,950
star formation they correspond to the

902
00:47:43,049 --> 00:47:39,920
older star formation as well so we have

903
00:47:45,819 --> 00:47:43,059
to again to separate that component of

904
00:47:48,579 --> 00:47:45,829
dust which is not related to the

905
00:47:50,829 --> 00:47:48,589
current star formation and that also

906
00:47:52,569 --> 00:47:50,839
means separating the light how are we

907
00:47:54,400 --> 00:47:52,579
going to separate the right but the

908
00:48:00,249 --> 00:47:54,410
problem is okay we have to separate it

909
00:48:04,239 --> 00:48:00,259
and not everybody is thinking and so

910
00:48:08,199 --> 00:48:04,249
what the diffuse background so all this

911
00:48:10,660 --> 00:48:08,209
light which is not related to the

912
00:48:13,089 --> 00:48:10,670
current star formation I call it diffuse

913
00:48:18,009 --> 00:48:13,099

background okay and we have to separate

914
00:48:22,089 --> 00:48:18,019
that thing and in one of my works I used

915
00:48:24,880 --> 00:48:22,099
a software where I separated these the

916
00:48:27,910 --> 00:48:24,890
younger star forming regions from the

917
00:48:30,849 --> 00:48:27,920
diffuse background so for example here

918
00:48:32,589 --> 00:48:30,859
there is this one galaxy NGC is there

919
00:48:35,229 --> 00:48:32,599
are six to eight one of the galaxies in

920
00:48:38,349 --> 00:48:35,239
my sample these are the original images

921
00:48:41,559 --> 00:48:38,359
taken in far ultraviolet optical and

922
00:48:47,559 --> 00:48:41,569
infrared now that software was applied

923
00:48:50,589 --> 00:48:47,569
and this middle panel it potentially

924
00:48:52,809 --> 00:48:50,599
contains the star forming regions which

925
00:48:56,559 --> 00:48:52,819
corresponds to only the current star

926
00:49:00,729 --> 00:48:56,569
formation okay and here is the old

927
00:49:02,229 --> 00:49:00,739
unrelated diffuse stuff so that so why

928
00:49:04,359 --> 00:49:02,239
it is called diffuse also because it

929
00:49:06,009 --> 00:49:04,369
looks very diffuse here so that is one

930
00:49:09,309 --> 00:49:06,019
of the reasons it's called diffuse

931
00:49:14,920 --> 00:49:09,319
background so now how do we apply

932
00:49:17,259 --> 00:49:14,930
everything and how we can improve the

933
00:49:21,969 --> 00:49:17,269
works which because I'm talking about a

934
00:49:28,630 --> 00:49:21,979
work that was that started in 1959 now

935
00:49:33,640 --> 00:49:28,640
in 1998 Rob connect it he assemble data

936
00:49:35,380 --> 00:49:33,650
of 100 galaxies and then so what he

937
00:49:38,109 --> 00:49:35,390
assembled was star formation rate

938
00:49:40,660 --> 00:49:38,119

density and gas surface density and then

939
00:49:43,569 --> 00:49:40,670
he made a plot where there is star

940
00:49:46,299 --> 00:49:43,579
formation density and gas surface

941
00:49:49,120 --> 00:49:46,309
density and he estimated the value of n

942
00:49:51,279 --> 00:49:49,130
now I told you everybody in the not

943
00:49:53,650 --> 00:49:51,289
everybody okay not everybody works on

944
00:49:58,329 --> 00:49:53,660
the same thing but yeah a lot of people

945
00:49:59,410 --> 00:49:58,339
in the world are working on finding the

946
00:50:03,520 --> 00:49:59,420
value of n

947
00:50:06,150 --> 00:50:03,530
okay so why everybody is doing that if

948
00:50:11,079 --> 00:50:06,160
he has he already did it

949
00:50:14,680 --> 00:50:11,089
the thing is in 1998 the instruments

950
00:50:17,980 --> 00:50:14,690
which we had were not that powerful

951
00:50:21,370 --> 00:50:17,990
enough that they could go into much

952
00:50:23,950 --> 00:50:21,380
detail so what he had assembled where

953
00:50:27,250 --> 00:50:23,960
the star formation rate density and gas

954
00:50:32,319 --> 00:50:27,260
density of entire galaxies and not the

955
00:50:34,240 --> 00:50:32,329
star forming regions okay now for

956
00:50:39,130 --> 00:50:34,250
example this is one of the galaxies that

957
00:50:41,950 --> 00:50:39,140
I showed you earlier in GC 0 6 to 8 here

958
00:50:44,740 --> 00:50:41,960
what we see is that there are several

959
00:50:49,599 --> 00:50:44,750
star forming regions there is gas just

960
00:50:51,339 --> 00:50:49,609
and it's not uniform it's like the

961
00:50:53,740 --> 00:50:51,349
population in the world there are

962
00:50:56,200 --> 00:50:53,750
certain regions where the population is

963
00:50:59,650 --> 00:50:56,210

very high there are certain regions

964
00:51:02,470 --> 00:50:59,660
where the population is very low so if

965
00:51:05,079 --> 00:51:02,480
for example for the entire galaxy I

966
00:51:08,049 --> 00:51:05,089
assign just one value of star formation

967
00:51:11,740 --> 00:51:08,059
rate density and one value of gas

968
00:51:14,200 --> 00:51:11,750
surface density that's not that's

969
00:51:17,289 --> 00:51:14,210
actually a very big approximation and it

970
00:51:18,819 --> 00:51:17,299
should not be done well it can be done

971
00:51:22,569 --> 00:51:18,829
because it solved a lot of our questions

972
00:51:25,359 --> 00:51:22,579
but then to understand how stars form we

973
00:51:29,880 --> 00:51:25,369
should actually see what is happening at

974
00:51:32,380 --> 00:51:29,890
the scales of star-forming regions so

975
00:51:34,780 --> 00:51:32,390
this is the same plot which I showed

976
00:51:36,970 --> 00:51:34,790
earlier showed you earlier star

977
00:51:39,809 --> 00:51:36,980
formation rate density gas surface

978
00:51:46,020 --> 00:51:39,819
density and here on this plot actually

979
00:51:49,120 --> 00:51:46,030
each point was a galaxy I generated

980
00:51:52,480 --> 00:51:49,130
several of such plots where each data

981
00:51:54,400 --> 00:51:52,490
point was not a galaxy but it was a

982
00:51:57,069 --> 00:51:54,410
star-forming region and not only me

983
00:52:00,579 --> 00:51:57,079
there are several people working on such

984
00:52:03,490 --> 00:52:00,589
things because we have such technologies

985
00:52:07,480 --> 00:52:03,500
available now which allow us to probe

986
00:52:11,319 --> 00:52:07,490
star forming regions so what I meant by

987
00:52:13,019 --> 00:52:11,329
replacing each galaxy with several of

988
00:52:17,009 --> 00:52:13,029

star forming regions

989
00:52:21,929 --> 00:52:17,019
this here's again this galaxy NGC 0 6 to

990
00:52:25,349 --> 00:52:21,939
8 the whole galaxy is for example this

991
00:52:27,059 --> 00:52:25,359
red circle the galaxy is about sixty

992
00:52:29,729 --> 00:52:27,069
thousand light-years across

993
00:52:32,699 --> 00:52:29,739
I put several I find several star

994
00:52:34,529 --> 00:52:32,709
forming regions there and the dimension

995
00:52:38,689 --> 00:52:34,539
of that is around fifteen hundred

996
00:52:42,289 --> 00:52:38,699
light-years if you compare the two this

997
00:52:45,779 --> 00:52:42,299
dimension is about forty times smaller

998
00:52:48,359 --> 00:52:45,789
and the thing is with technologies which

999
00:52:51,149 --> 00:52:48,369
we have available now we can actually do

1000
00:52:53,579 --> 00:52:51,159
for such galaxies four thousand times

1001
00:52:55,559 --> 00:52:53,589
mother okay so I have I have studied

1002
00:52:58,229 --> 00:52:55,569
that those things as well but in a

1003
00:53:02,449 --> 00:52:58,239
different context so that's very

1004
00:53:05,429 --> 00:53:02,459
interesting we use this thing and then

1005
00:53:09,509 --> 00:53:05,439
before going in further I will I would

1006
00:53:13,699 --> 00:53:09,519
also like to show you actually show you

1007
00:53:18,659 --> 00:53:13,709
the approach to solve the problem of

1008
00:53:20,880 --> 00:53:18,669
death attenuation okay so and this is

1009
00:53:23,939 --> 00:53:20,890
zero six to eight the same galaxy which

1010
00:53:25,799 --> 00:53:23,949
I have been showing you for quite some

1011
00:53:28,589 --> 00:53:25,809
time they are in the three different

1012
00:53:33,019 --> 00:53:28,599
wavelength bands optical far ultraviolet

1013
00:53:38,140 --> 00:53:33,029

infrared so can someone tell me what

1014
00:53:45,170 --> 00:53:40,849
it was for ionized gas

1015
00:53:48,410 --> 00:53:45,180
okay dust was infrared and far

1016
00:53:52,670 --> 00:53:48,420
ultraviolet was stars okay so we have

1017
00:53:54,950 --> 00:53:52,680
images of the same galaxy in three

1018
00:53:56,630 --> 00:53:54,960
different beta and bands and why do we

1019
00:53:58,460 --> 00:53:56,640
want to do that because then we are

1020
00:54:01,250 --> 00:53:58,470
measuring different components of a

1021
00:54:03,560 --> 00:54:01,260
star-forming region or a galaxy now we

1022
00:54:07,040 --> 00:54:03,570
want to combine actually optical and

1023
00:54:10,550 --> 00:54:07,050
infrared because then we will be able to

1024
00:54:12,920 --> 00:54:10,560
get back the light which was absorbed by

1025
00:54:15,410 --> 00:54:12,930
the test and then we have the complete

1026
00:54:18,010 --> 00:54:15,420
picture of a star-forming region we have

1027
00:54:21,320 --> 00:54:18,020
the light emitted from the Stars and

1028
00:54:24,230 --> 00:54:21,330
also that was obscured by the dust and

1029
00:54:26,750 --> 00:54:24,240
then we use a conversion factor and

1030
00:54:28,880 --> 00:54:26,760
estimate star formation rate so that is

1031
00:54:33,770 --> 00:54:28,890
how we measure star formation rate

1032
00:54:38,120 --> 00:54:33,780
taking into account of dust and removing

1033
00:54:40,250 --> 00:54:38,130
a diffuse background now till now I had

1034
00:54:43,280 --> 00:54:40,260
been talking about star formation rate

1035
00:54:44,930 --> 00:54:43,290
but in this equation which I showed you

1036
00:54:47,510 --> 00:54:44,940
earlier there was the star formation

1037
00:54:50,930 --> 00:54:47,520
rate density and there was this gas

1038
00:54:55,160 --> 00:54:50,940

density so what about gas which gas form

1039
00:54:59,780 --> 00:54:55,170
stars so this is a very big topic in

1040
00:55:02,720 --> 00:54:59,790
itself which gas form stars how do we

1041
00:55:07,550 --> 00:55:02,730
measure the gas content of galaxies so

1042
00:55:10,810 --> 00:55:07,560
if we look at the typical star forming

1043
00:55:13,760 --> 00:55:10,820
region again we have this gas here and

1044
00:55:17,599 --> 00:55:13,770
this gas can be present in different

1045
00:55:20,570 --> 00:55:17,609
forms it can be ionized or it can be

1046
00:55:24,620 --> 00:55:20,580
neutral the neutral gas and it can be

1047
00:55:28,400 --> 00:55:24,630
hot it can be warm it can be cold and it

1048
00:55:30,680 --> 00:55:28,410
is thought that star form in neutral gas

1049
00:55:32,630 --> 00:55:30,690
coal neutral gas and the coal neutral

1050
00:55:36,520 --> 00:55:32,640
gas can be present in two different

1051
00:55:40,579 --> 00:55:36,530
forms they can be atomic and molecular

1052
00:55:44,000 --> 00:55:40,589
and the most abundant atom in the

1053
00:55:47,240 --> 00:55:44,010
universe is hydrogen

1054
00:55:49,880 --> 00:55:47,250
and it is observed at 21 centimeter or

1055
00:55:54,470 --> 00:55:49,890
1420 megahertz and the most abundant

1056
00:55:57,260 --> 00:55:54,480
molecule in the universe is hydrogen

1057
00:56:00,440 --> 00:55:57,270
Valkyr but the problem is that hydrogen

1058
00:56:03,860 --> 00:56:00,450
does not hydrogen molecule does not emit

1059
00:56:07,550 --> 00:56:03,870
much of the radiation so it's very

1060
00:56:10,340 --> 00:56:07,560
difficult to measure the at a molecular

1061
00:56:12,980 --> 00:56:10,350
gas itself so what we do is we use

1062
00:56:15,770 --> 00:56:12,990
different kinds of proxies so those

1063
00:56:18,470 --> 00:56:15,780

proxies are like carbon monoxide or

1064
00:56:21,170 --> 00:56:18,480
hydrogen cyanide there are several other

1065
00:56:24,230 --> 00:56:21,180
molecules as well but when we use these

1066
00:56:26,030 --> 00:56:24,240
proxies there are several factors which

1067
00:56:29,600 --> 00:56:26,040
come in for example the metal content

1068
00:56:36,170 --> 00:56:29,610
and so that is also an active area of

1069
00:56:39,110 --> 00:56:36,180
research so now going back to 1959 what

1070
00:56:42,530 --> 00:56:39,120
Martin Smith did when he gave this

1071
00:56:44,990 --> 00:56:42,540
Smith's relation of between star

1072
00:56:48,950 --> 00:56:45,000
formation rate and gas he actually

1073
00:56:53,210 --> 00:56:48,960
considered the total gas total gas means

1074
00:56:56,900 --> 00:56:53,220
Atma gas and molecular gas fast-forward

1075
00:57:00,200 --> 00:56:56,910
in 1998 when Roth Kennecott studied

1076
00:57:03,950 --> 00:57:00,210
Smith's relation for entire galaxies he

1077
00:57:06,140 --> 00:57:03,960
also found that it is the totally gas

1078
00:57:08,060 --> 00:57:06,150
that is the combination of atomic and

1079
00:57:13,070 --> 00:57:08,070
molecular gas which leads to the

1080
00:57:16,130 --> 00:57:13,080
formation of stars so but at local

1081
00:57:18,980 --> 00:57:16,140
scales we don't know what happens for

1082
00:57:21,470 --> 00:57:18,990
example here is the Atma gas map and the

1083
00:57:23,510 --> 00:57:21,480
molecular gas map of the same galaxy now

1084
00:57:27,490 --> 00:57:23,520
you would say what is happening here why

1085
00:57:31,980 --> 00:57:27,500
how I put a smaller picture here

1086
00:57:36,280 --> 00:57:34,360
yeah actually it's it's towards the

1087
00:57:38,980 --> 00:57:36,290
middle it's so what happens is that

1088
00:57:40,750 --> 00:57:38,990

atomic gas is spread all over the galaxy

1089
00:57:45,370 --> 00:57:40,760
but molecular gas is just found in the

1090
00:57:47,860 --> 00:57:45,380
center so now I'm showing again the

1091
00:57:49,450 --> 00:57:47,870
atomic gas map mostly gas map and let's

1092
00:57:52,510 --> 00:57:49,460
compare that with the total star

1093
00:57:56,830 --> 00:57:52,520
formation rate here the lighter shades

1094
00:57:59,410 --> 00:57:56,840
that is lower intensity and darker

1095
00:58:02,170 --> 00:57:59,420
shades higher intensity if we compare

1096
00:58:05,680 --> 00:58:02,180
these gas maps with the star formation

1097
00:58:07,950 --> 00:58:05,690
rate can you say which gas could be

1098
00:58:11,680 --> 00:58:07,960
leading to the formation of stars

1099
00:58:15,010 --> 00:58:11,690
molecular gas right you can you can say

1100
00:58:17,380 --> 00:58:15,020
that right away but it's a very

1101
00:58:18,930 --> 00:58:17,390
complicated topic and not everybody

1102
00:58:21,910 --> 00:58:18,940
thinks not even me

1103
00:58:25,960 --> 00:58:21,920
things that it is the monthly gas which

1104
00:58:27,880 --> 00:58:25,970
leads which is only related to the star

1105
00:58:30,370 --> 00:58:27,890
formation rate because even the

1106
00:58:34,000 --> 00:58:30,380
molecular gas is formed from the atomic

1107
00:58:36,820 --> 00:58:34,010
gas and many astrophysics physicists

1108
00:58:39,300 --> 00:58:36,830
think that there is some other

1109
00:58:42,400 --> 00:58:39,310
phenomenon which is simultaneously

1110
00:58:47,650 --> 00:58:42,410
affecting the formation of molecular gas

1111
00:58:52,000 --> 00:58:47,660
and also the formation of stars and that

1112
00:58:58,270 --> 00:58:52,010
could be just so this is a evolving

1113
00:59:00,330 --> 00:58:58,280

topic people are working on it and there

1114
00:59:03,210 --> 00:59:00,340
are several approaches like further

1115
00:59:06,340 --> 00:59:03,220
approaches to to address these questions

1116
00:59:08,460 --> 00:59:06,350
so for example some of these are listed

1117
00:59:12,010 --> 00:59:08,470
here I will go through them one by one

1118
00:59:14,140 --> 00:59:12,020
so the first one is let's invade

1119
00:59:16,660 --> 00:59:14,150
investigate other aspects of star

1120
00:59:18,310 --> 00:59:16,670
formation so for example when I showed

1121
00:59:20,950 --> 00:59:18,320
you a typical star forming region there

1122
00:59:23,170 --> 00:59:20,960
was this stars gas test but to

1123
00:59:25,540 --> 00:59:23,180
understand what happens how stars are

1124
00:59:28,150 --> 00:59:25,550
formed we have to look at the bigger

1125
00:59:31,650 --> 00:59:28,160
picture like in a star-forming galaxy so

1126
00:59:34,900 --> 00:59:31,660
stars form from gas and gas is either

1127
00:59:37,240 --> 00:59:34,910
accreted in the galaxies or they're

1128
00:59:39,970 --> 00:59:37,250
formed Institute then inside the stars

1129
00:59:42,520 --> 00:59:39,980
metals are formed and then when the

1130
00:59:44,090 --> 00:59:42,530
stars explode they are dispersed into

1131
00:59:48,880 --> 00:59:44,100
the interstellar medium which is

1132
00:59:51,980 --> 00:59:48,890
again taken in taken outside or probably

1133
00:59:54,230 --> 00:59:51,990
redistributed in the galaxy so if we

1134
00:59:58,310 --> 00:59:54,240
look at the distribution of the metal

1135
01:00:00,080 --> 00:59:58,320
content within the galaxies then we can

1136
01:00:02,840 --> 01:00:00,090
also infer a lot about the star

1137
01:00:05,450 --> 01:00:02,850
formation so how do we measure the metal

1138
01:00:09,530 --> 01:00:05,460

content we use a spectroscope a

1139
01:00:11,810 --> 01:00:09,540
spectroscope gives us the spectrum shown

1140
01:00:14,600 --> 01:00:11,820
here of a star-forming region or a

1141
01:00:17,360 --> 01:00:14,610
galaxy and there are emission lines

1142
01:00:23,180 --> 01:00:17,370
which you can use to measure the metal

1143
01:00:25,220 --> 01:00:23,190
content now the next approach to address

1144
01:00:27,020 --> 01:00:25,230
those questions is investigating other

1145
01:00:29,420 --> 01:00:27,030
types of galaxies for example the

1146
01:00:32,330 --> 01:00:29,430
galaxies I showed you earlier all of

1147
01:00:35,210 --> 01:00:32,340
those galaxies were dominated by

1148
01:00:37,670 --> 01:00:35,220
molecular gas in their center but there

1149
01:00:39,890 --> 01:00:37,680
are galaxies which are forming stars but

1150
01:00:42,110 --> 01:00:39,900
they have we don't detect molecular gas

1151
01:00:43,760 --> 01:00:42,120
in them there are atomic gas they are

1152
01:00:47,720 --> 01:00:43,770
dominated by two main gas for example

1153
01:00:49,520 --> 01:00:47,730
NGC 2403 it is one of such galaxies and

1154
01:00:52,910 --> 01:00:49,530
these pink regions are star forming

1155
01:00:55,190 --> 01:00:52,920
regions so it will be interesting to

1156
01:00:57,500 --> 01:00:55,200
investigate these galaxies and some

1157
01:01:00,130 --> 01:00:57,510
other galaxies like these galaxies the

1158
01:01:05,300 --> 01:01:00,140
irregular galaxies I mentioned earlier

1159
01:01:07,760 --> 01:01:05,310
these galaxies are actually the local

1160
01:01:10,280 --> 01:01:07,770
analogs of Hydra ship galaxies hi - it

1161
01:01:12,770 --> 01:01:10,290
means very distant galaxies okay so

1162
01:01:14,450 --> 01:01:12,780
these galaxies have very high star

1163
01:01:17,420 --> 01:01:14,460

formation rate and their metal content

1164
01:01:20,410 --> 01:01:17,430
is very low I work on these galaxies and

1165
01:01:24,080 --> 01:01:20,420
they are quite in exciting to work on

1166
01:01:25,730 --> 01:01:24,090
because of the upcoming instruments

1167
01:01:30,170 --> 01:01:25,740
which are focused on the high rest on

1168
01:01:32,750 --> 01:01:30,180
the distant galaxies and then probing

1169
01:01:36,440 --> 01:01:32,760
even smaller skills for example I showed

1170
01:01:38,480 --> 01:01:36,450
you the spiral galaxy which is 60,000

1171
01:01:41,360 --> 01:01:38,490
light years across the study was done

1172
01:01:43,070 --> 01:01:41,370
for 1500 light years across regions but

1173
01:01:45,650 --> 01:01:43,080
the Orion Nebula is twenty four light

1174
01:01:49,520 --> 01:01:45,660
years across so we need to probe these

1175
01:01:53,030 --> 01:01:49,530
regions for which we need very powerful

1176
01:01:55,520 --> 01:01:53,040
instruments now let's look at a few

1177
01:01:57,160 --> 01:01:55,530
instruments which were used in the works

1178
01:02:02,020 --> 01:01:57,170
I have shown you till now

1179
01:02:05,530 --> 01:02:02,030
KPN Oh which observes in optical galaxy

1180
01:02:09,130 --> 01:02:05,540
Explorer which you which used to observe

1181
01:02:10,510 --> 01:02:09,140
in far ultra in ultraviolet actually

1182
01:02:12,940 --> 01:02:10,520
both far ultraviolet and near Earth

1183
01:02:15,660 --> 01:02:12,950
ultraviolet Spitzer which was named

1184
01:02:20,620 --> 01:02:15,670
after Lyman Spitzer it was for infrared

1185
01:02:22,780 --> 01:02:20,630
Iran that is in Spain and that allows us

1186
01:02:23,589 --> 01:02:22,790
to study the multi gas content of

1187
01:02:29,289 --> 01:02:23,599
galaxies

1188
01:02:32,049 --> 01:02:29,299

VLA that is that allows us to estimate

1189
01:02:34,059 --> 01:02:32,059
the Atma gas content of galaxies so I

1190
01:02:37,270 --> 01:02:34,069
showed you these instruments because

1191
01:02:38,740 --> 01:02:37,280
they were relevant to the works I had

1192
01:02:45,039 --> 01:02:38,750
shown you but there are several other

1193
01:02:47,620 --> 01:02:45,049
instruments and the and the interesting

1194
01:02:50,049 --> 01:02:47,630
point is that most of these instruments

1195
01:02:53,470 --> 01:02:50,059
like all of these instruments they are

1196
01:02:55,690 --> 01:02:53,480
either photometric they can do either

1197
01:02:58,059 --> 01:02:55,700
photometry that is take images or they

1198
01:03:00,809 --> 01:02:58,069
can do spectroscopy that is taking

1199
01:03:03,700 --> 01:03:00,819
spectra but now we have this very

1200
01:03:05,589 --> 01:03:03,710
powerful technology which is called

1201
01:03:07,510 --> 01:03:05,599
integral field spectroscopy which

1202
01:03:09,190 --> 01:03:07,520
combines the power of the two that is

1203
01:03:11,920 --> 01:03:09,200
you can do photo metree and spectroscopy

1204
01:03:14,770 --> 01:03:11,930
at the same time and you can measure

1205
01:03:18,190 --> 01:03:14,780
star formation gas content metal content

1206
01:03:20,589 --> 01:03:18,200
for each pixel in your image and that is

1207
01:03:23,620 --> 01:03:20,599
very powerful some of these telescopes

1208
01:03:26,140 --> 01:03:23,630
are mu instruments are mules on very

1209
01:03:29,349 --> 01:03:26,150
large telescope we'pon William Herschel

1210
01:03:35,049 --> 01:03:29,359
telescope kcw eye on Keck you might have

1211
01:03:37,839 --> 01:03:35,059
heard of it and now JWST almost

1212
01:03:42,390 --> 01:03:37,849
everybody in the world who is interested

1213
01:03:45,280 --> 01:03:42,400

in astronomy knows about JWST this is a

1214
01:03:47,170 --> 01:03:45,290
telescope which is very which which

1215
01:03:49,329 --> 01:03:47,180
would be very useful for me because it

1216
01:03:51,430 --> 01:03:49,339
has two instruments which can do

1217
01:03:55,480 --> 01:03:51,440
integral field spectroscopy I explained

1218
01:03:57,940 --> 01:03:55,490
just now and those instruments are

1219
01:04:01,539 --> 01:03:57,950
NIRSPEC or Meili and maybe you might

1220
01:04:04,210 --> 01:04:01,549
have heard about them so JWST is

1221
01:04:06,839 --> 01:04:04,220
scheduled to be launched in 2021 and

1222
01:04:10,690 --> 01:04:06,849
this is going to be the largest

1223
01:04:13,809 --> 01:04:10,700
telescope in space so let's have a

1224
01:04:34,830 --> 01:04:13,819
look at this video why this telescope is

1225
01:07:23,710 --> 01:04:40,470
[Music]

1226
01:07:27,050 --> 01:07:24,920
okay

1227
01:07:32,240 --> 01:07:27,060
so I hope you liked the video there is

1228
01:07:34,970 --> 01:07:32,250
this last thing last last thing about an

1229
01:07:36,800 --> 01:07:34,980
opportunity happening here in Space

1230
01:07:40,240 --> 01:07:36,810
Telescope Science Institute in summer

1231
01:07:48,140 --> 01:07:40,250
it's the space shahnameh summer program

1232
01:07:51,140 --> 01:07:48,150
2020 I was a student in 2013 as a part

1233
01:07:54,770 --> 01:07:51,150
of this program you can find me here I'm

1234
01:07:58,040 --> 01:07:54,780
here with all of my friends and now last

1235
01:08:00,920 --> 01:07:58,050
year I joined here in Space Telescope

1236
01:08:05,030 --> 01:08:00,930
Science Institute as an astronomer so it

1237
01:08:08,470 --> 01:08:05,040
is a real great opportunity so last year

1238
01:08:10,820 --> 01:08:08,480

in 2019 there were these young students

1239
01:08:12,350 --> 01:08:10,830
young summer students who worked on

1240
01:08:13,910 --> 01:08:12,360
different topics there were five

1241
01:08:15,830 --> 01:08:13,920
international students there were also

1242
01:08:21,080 --> 01:08:15,840
some local students from University of

1243
01:08:24,970 --> 01:08:21,090
Maryland and Towson and this year 2020 I

1244
01:08:30,800 --> 01:08:24,980
have proposed two projects which are

1245
01:08:34,540 --> 01:08:30,810
based on tape jam from the ifu

1246
01:08:37,340 --> 01:08:34,550
instruments the technology I just

1247
01:08:40,100 --> 01:08:37,350
explained that combines photomeatery and

1248
01:08:43,070 --> 01:08:40,110
spectroscopy and that those data are

1249
01:08:46,240 --> 01:08:43,080
from Keck and from very large Space

1250
01:08:50,110 --> 01:08:46,250
Telescope so I strongly encourage

1251
01:08:54,250 --> 01:08:50,120
students to apply for this program

1252
01:08:57,230 --> 01:08:54,260
applications are now open it was a real

1253
01:08:58,880 --> 01:08:57,240
opportunity for me I really enjoyed my

1254
01:09:01,340 --> 01:08:58,890
time and it was one of the most

1255
01:09:03,740 --> 01:09:01,350
rewarding experiences of my life so I

1256
01:09:05,730 --> 01:09:03,750
really encourage the students thank you

1257
01:09:12,959 --> 01:09:05,740
so much for your family

1258
01:09:24,090 --> 01:09:12,969
[Applause]

1259
01:09:28,200 --> 01:09:24,100
I handle some questions turn my

1260
01:09:30,059 --> 01:09:28,210
microphone back on hi I'm back all right

1261
01:09:41,630 --> 01:09:30,069
we have questions for our speaker how

1262
01:09:44,789 --> 01:09:41,640
about right there we'll start there so

1263
01:09:49,079 --> 01:09:44,799

what happens is that when I did my work

1264
01:09:52,019 --> 01:09:49,089
the value I got agrees with the value

1265
01:10:03,600 --> 01:09:52,029
with Schwab cannikin cot in 1998 and the

1266
01:10:08,510 --> 01:10:03,610
value is 1 point 4 describes gasps is

1267
01:10:11,850 --> 01:10:08,520
having expansive qualities I'll call it

1268
01:10:16,130 --> 01:10:11,860
and I don't understand why it isn't

1269
01:10:19,320 --> 01:10:16,140
simply inertial resistance to collapse

1270
01:10:23,250 --> 01:10:19,330
why are you called why is it expansive

1271
01:10:27,000 --> 01:10:23,260
in any way so there are different well

1272
01:10:29,970 --> 01:10:27,010
that's right so there are different

1273
01:10:32,220 --> 01:10:29,980
factors which are affecting the

1274
01:10:34,500 --> 01:10:32,230
formation of stars but when we look at a

1275
01:10:36,660 --> 01:10:34,510
star forming region there is this

1276
01:10:38,400 --> 01:10:36,670
gravitational collapse like there is

1277
01:10:40,830 --> 01:10:38,410
this gravitational force there is

1278
01:10:46,410 --> 01:10:40,840
pressure there is turbulence there are

1279
01:10:49,950 --> 01:10:46,420
several there are several it is

1280
01:10:53,540 --> 01:10:49,960
resisting collapse yes I don't

1281
01:10:57,479 --> 01:10:53,550
understand why why is it just there and

1282
01:11:00,689 --> 01:10:57,489
and having inertia that's resisting

1283
01:11:02,310 --> 01:11:00,699
collapse so what is it that you don't

1284
01:11:05,490 --> 01:11:02,320
understand I don't understand why the

1285
01:11:07,380 --> 01:11:05,500
word pressure is involved the

1286
01:11:09,840 --> 01:11:07,390
description of the gas is he not

1287
01:11:11,100 --> 01:11:09,850
catching that the the gas has a

1288
01:11:12,750 --> 01:11:11,110

temperature to it and the thermal

1289
01:11:15,930 --> 01:11:12,760
pressure always pushes is going to put

1290
01:11:17,970 --> 01:11:15,940
it provide resistance against it so when

1291
01:11:20,430 --> 01:11:17,980
you have a gas at a certain temperature

1292
01:11:22,169 --> 01:11:20,440
by the ideal gas law you have a pressure

1293
01:11:25,080 --> 01:11:22,179
associated with that temperature and

1294
01:11:26,120 --> 01:11:25,090
that is going to resist the inward

1295
01:11:27,680 --> 01:11:26,130
pressure the

1296
01:11:30,620 --> 01:11:27,690
inward force due to gravity or other

1297
01:11:33,680 --> 01:11:30,630
things thanks Frank yeah yeah yeah thank

1298
01:11:35,720 --> 01:11:33,690
you Frank you all right right behind you

1299
01:11:42,100 --> 01:11:35,730
there's a young gentleman who had a head

1300
01:11:43,730 --> 01:11:42,110
his hand up I'm just going to ask

1301
01:11:47,930 --> 01:11:43,740
beetlejuice

1302
01:11:56,390 --> 01:11:47,940
stars oh all right and the constellation

1303
01:12:03,700 --> 01:11:56,400
is named after well Wikipedia we'll have

1304
01:12:10,640 --> 01:12:07,220
all right so the question was Betelgeuse

1305
01:12:12,080 --> 01:12:10,650
oh yeah so Americans have there was this

1306
01:12:16,010 --> 01:12:12,090
movie with Michael Keaton in it called

1307
01:12:18,280 --> 01:12:16,020
Betelgeuse spelled beetle as in the bug

1308
01:12:21,170 --> 01:12:18,290
beetle and juice as in like orange juice

1309
01:12:23,630 --> 01:12:21,180
and so so many Americans pronounce it as

1310
01:12:26,240 --> 01:12:23,640
Beetlejuice when it's baitul juice okay

1311
01:12:29,150 --> 01:12:26,250
and they sort of think that the movie

1312
01:12:33,080 --> 01:12:29,160
and and yet know the movie isn't even

1313
01:12:36,110 --> 01:12:33,090

named after the star it's a total it's a

1314
01:12:37,280 --> 01:12:36,120
it's a transformation of the name into

1315
01:12:40,100 --> 01:12:37,290
into something weird

1316
01:12:42,650 --> 01:12:40,110
yes you probably being permittee you may

1317
01:12:44,120 --> 01:12:42,660
not have seen that movie Michael Keaton

1318
01:12:48,440 --> 01:12:44,130
was it was long ago

1319
01:12:50,420 --> 01:12:48,450
nothing if it helps you remember the

1320
01:12:54,920 --> 01:12:50,430
name of the star though mission

1321
01:12:57,860 --> 01:12:54,930
accomplished okay and by the way if you

1322
01:13:02,690 --> 01:12:57,870
haven't heard battle juice is actually

1323
01:13:04,220 --> 01:13:02,700
dimming and we're not sure why we expect

1324
01:13:06,980 --> 01:13:04,230
it to brighten start brightening back up

1325
01:13:08,680 --> 01:13:06,990
this month or next month and if it

1326
01:13:10,970 --> 01:13:08,690
doesn't happen this month or next month

1327
01:13:11,870 --> 01:13:10,980
something really interesting is going on

1328
01:13:14,300 --> 01:13:11,880
there okay

1329
01:13:15,860 --> 01:13:14,310
it has some pulsation cycles and we can

1330
01:13:17,510 --> 01:13:15,870
sort of explain what's going on right

1331
01:13:19,880 --> 01:13:17,520
now by some of these pulsation cycles

1332
01:13:24,290 --> 01:13:19,890
but if it doesn't change out of this

1333
01:13:25,940 --> 01:13:24,300
cycle yeah kind of interesting I'm gonna

1334
01:13:31,010 --> 01:13:25,950
cheat and ask to question there's one

1335
01:13:33,980 --> 01:13:31,020
question what exactly is dust and does

1336
01:13:36,440 --> 01:13:33,990
it contribute in any way to star

1337
01:13:38,840 --> 01:13:36,450
formation yes

1338
01:13:44,180 --> 01:13:38,850

so what exactly is this

1339
01:13:46,100 --> 01:13:44,190
I just are well there are different

1340
01:13:48,350 --> 01:13:46,110
types of tests for example there are

1341
01:13:52,000 --> 01:13:48,360
silicate particles or carbonaceous

1342
01:13:55,310 --> 01:13:52,010
particles there are fully aromatic

1343
01:13:58,130 --> 01:13:55,320
polychromatic aromatic hydrocarbons

1344
01:14:00,230 --> 01:13:58,140
those are dust so dust is made up of

1345
01:14:03,680 --> 01:14:00,240
different kind of molecules or atoms

1346
01:14:05,690 --> 01:14:03,690
grains so that is dust and your second

1347
01:14:10,130 --> 01:14:05,700
question was if it affects the formation

1348
01:14:14,050 --> 01:14:10,140
of stars yeah so for example some people

1349
01:14:18,290 --> 01:14:14,060
also think that just actually leads to

1350
01:14:21,290 --> 01:14:18,300
like dust acts as a catalyst for the

1351
01:14:24,470 --> 01:14:21,300
formation of molecules from atoms so in

1352
01:14:27,770 --> 01:14:24,480
that way that might lead to the

1353
01:14:29,210 --> 01:14:27,780
formation of stars so for example highly

1354
01:14:32,720 --> 01:14:29,220
star forming regions they are highly

1355
01:14:33,560 --> 01:14:32,730
dusty as well ok we have a question from

1356
01:14:36,290 --> 01:14:33,570
online

1357
01:14:38,770 --> 01:14:36,300
how strong are the magnetic fields in

1358
01:14:41,090 --> 01:14:38,780
these molecular clouds and does that

1359
01:14:43,240 --> 01:14:41,100
affect star formation as I guess what

1360
01:14:47,690 --> 01:14:43,250
the question would be yeah so there are

1361
01:14:51,140 --> 01:14:47,700
theoretical works going on about how we

1362
01:14:52,670 --> 01:14:51,150
can incorporate magnetic fields like

1363
01:14:56,500 --> 01:14:52,680

theoretical works actually mostly

1364
01:14:59,240 --> 01:14:56,510
theoretical works to understand the

1365
01:15:01,160 --> 01:14:59,250
effect of magnetic fields on the

1366
01:15:04,910 --> 01:15:01,170
formation of stars so that magnetic

1367
01:15:09,070 --> 01:15:04,920
magnetic field turbulence gas pressure

1368
01:15:11,420 --> 01:15:09,080
density gravitational force all of these

1369
01:15:14,290 --> 01:15:11,430
factors play an important role in the

1370
01:15:22,510 --> 01:15:14,300
formation of stars yes

1371
01:15:27,410 --> 01:15:22,520
how much gas mass is needed to begin oh

1372
01:15:28,130 --> 01:15:27,420
that is so that is exactly what James

1373
01:15:33,590 --> 01:15:28,140
Gene's

1374
01:15:38,180 --> 01:15:33,600
did he gave this a recipe it's called

1375
01:15:41,660 --> 01:15:38,190
jeans mask which is based on density and

1376
01:15:45,410 --> 01:15:41,670
temperature and for a given density so

1377
01:15:48,530 --> 01:15:45,420
it depends on it not it's not it is not

1378
01:15:50,600 --> 01:15:48,540
only the gas mass but it also depends on

1379
01:15:52,500 --> 01:15:50,610
what is the density and what is the

1380
01:15:56,100 --> 01:15:52,510
temperature and from this day

1381
01:15:58,200 --> 01:15:56,110
and temperature we can estimate the gas

1382
01:16:01,140 --> 01:15:58,210
mass so the density and temperature

1383
01:16:05,129 --> 01:16:01,150
depends on the conditions in the gas

1384
01:16:07,560 --> 01:16:05,139
cloud so we have there's a related

1385
01:16:10,229 --> 01:16:07,570
question that people often ask is so if

1386
01:16:12,419 --> 01:16:10,239
you have you know a thousand solar mass

1387
01:16:14,310 --> 01:16:12,429
cloud how much of that is actually gonna

1388
01:16:17,060 --> 01:16:14,320

form into stars what percentage of that

1389
01:16:21,750 --> 01:16:17,070
actually makes it into stars

1390
01:16:23,879 --> 01:16:21,760
well I I don't really know but I I don't

1391
01:16:36,669 --> 01:16:23,889
really know but for example I can give

1392
01:16:45,069 --> 01:16:40,270
so here for example the gas density so

1393
01:16:46,929 --> 01:16:45,079
you said thousands of thousand or ten

1394
01:16:48,819 --> 01:16:46,939
thousand solar mass gas cloud people

1395
01:16:50,469 --> 01:16:48,829
asked questions with how am i matter

1396
01:16:53,049 --> 01:16:50,479
that makes no stars is it 1 percent or

1397
01:16:54,609 --> 01:16:53,059
is it 10 percent yes so that is actually

1398
01:16:56,859 --> 01:16:54,619
that is a question related to the

1399
01:16:58,929 --> 01:16:56,869
efficiency of star formation and

1400
01:17:02,169 --> 01:16:58,939
efficiency of star formation is very low

1401
01:17:03,879 --> 01:17:02,179
compared to what is available like it is

1402
01:17:07,109 --> 01:17:03,889
known to be very low and that is also a

1403
01:17:11,709 --> 01:17:07,119
question people are trying to understand

1404
01:17:13,810 --> 01:17:11,719
for theoretically for a given amount of

1405
01:17:15,580 --> 01:17:13,820
gas the star formation rate should be

1406
01:17:18,639 --> 01:17:15,590
very high but for some reason that

1407
01:17:23,020 --> 01:17:18,649
efficiency is so low it's about 1

1408
01:17:26,290 --> 01:17:23,030
percent 0.01 for example and here for

1409
01:17:32,139 --> 01:17:26,300
example I was just trying to give you an

1410
01:17:34,540 --> 01:17:32,149
estimate but I think it's fine earlier

1411
01:17:36,339 --> 01:17:34,550
Frank is shown a he was talking a little

1412
01:17:39,520 --> 01:17:36,349
bit about dark matter and how it was

1413
01:17:41,709 --> 01:17:39,530

inferred by I guess the gravity tried to

1414
01:17:44,469 --> 01:17:41,719
try to explain the rotation of galaxies

1415
01:17:47,409 --> 01:17:44,479
and and I've heard or read that there's

1416
01:17:49,750 --> 01:17:47,419
a lot of dark matter out there is could

1417
01:17:51,219 --> 01:17:49,760
that not be playing a role or are you

1418
01:17:52,419 --> 01:17:51,229
worried it might be missing something by

1419
01:17:58,899 --> 01:17:52,429
not taking something like that into

1420
01:18:03,119 --> 01:17:58,909
account well that might be but are these

1421
01:18:05,589 --> 01:18:03,129
scales I don't think that it matters so

1422
01:18:07,540 --> 01:18:05,599
he can't measure it I guess you can't

1423
01:18:10,000 --> 01:18:07,550
get it into the model but if there's so

1424
01:18:12,429 --> 01:18:10,010
much of it out there it makes you wonder

1425
01:18:14,409 --> 01:18:12,439
if there's yeah yeah I mean like people

1426
01:18:17,229 --> 01:18:14,419
are working tirelessly on understanding

1427
01:18:18,909 --> 01:18:17,239
the nature of dark matter and that when

1428
01:18:20,379 --> 01:18:18,919
we first understand its nature I think

1429
01:18:22,509 --> 01:18:20,389
that will become more easy to

1430
01:18:26,589 --> 01:18:22,519
incorporate such things in the stopping

1431
01:18:29,409 --> 01:18:26,599
which is already contradicted from from

1432
01:18:30,819 --> 01:18:29,419
a cosmologists point of view dark matter

1433
01:18:33,279 --> 01:18:30,829
is generally considered smoothly

1434
01:18:37,239 --> 01:18:33,289
distributed on galaxy scales it can be

1435
01:18:39,369 --> 01:18:37,249
clumpy on galaxy cluster scales but it's

1436
01:18:42,250 --> 01:18:39,379
relatively smooth across galaxies an

1437
01:18:43,600 --> 01:18:42,260
individual galaxy scale therefore it

1438
01:18:45,369 --> 01:18:43,610

wouldn't it would just be a background

1439
01:18:48,040 --> 01:18:45,379
field that's relatively smooth not

1440
01:18:49,569 --> 01:18:48,050
changing the star formation too much I'm

1441
01:18:49,910 --> 01:18:49,579
not a star formation expert but that's

1442
01:18:53,180 --> 01:18:49,920
from a

1443
01:18:55,580 --> 01:18:53,190
cosmologists point of view yeah when you

1444
01:18:57,709 --> 01:18:55,590
say dust are you talking about like the

1445
01:18:59,330 --> 01:18:57,719
kind of dust you might see on the street

1446
01:19:01,330 --> 01:18:59,340
or in the householder is it more like

1447
01:19:10,010 --> 01:19:01,340
cigarette smoke

1448
01:19:12,860 --> 01:19:10,020
carbon so these the test particles they

1449
01:19:15,020 --> 01:19:12,870
are they might be molecules atoms they

1450
01:19:18,260 --> 01:19:15,030
can be silicates carbonaceous particles

1451
01:19:20,390 --> 01:19:18,270
fully chromatic polychromatic aromatic

1452
01:19:24,080 --> 01:19:20,400
hydrocarbons so there are different kind

1453
01:19:27,050 --> 01:19:24,090
of things and if we look at the amount

1454
01:19:28,580 --> 01:19:27,060
of dust which is present in them in the

1455
01:19:30,410 --> 01:19:28,590
interstellar medium then we actually

1456
01:19:36,260 --> 01:19:30,420
won't be able to see each other in this

1457
01:19:38,200 --> 01:19:36,270
in this room it's so thick yeah other

1458
01:19:46,459 --> 01:19:38,210
questions

1459
01:19:52,340 --> 01:19:46,469
going once there we go good adjacent

1460
01:19:56,540 --> 01:19:52,350
stars ultraviolet radiation accelerate

1461
01:20:02,810 --> 01:19:56,550
or impede transition from atomic gas to

1462
01:20:06,080 --> 01:20:02,820
molecular gas the first part of your

1463
01:20:08,540 --> 01:20:06,090

question I just sent stars I think of in

1464
01:20:12,140 --> 01:20:08,550
the ultraviolet is tending to split

1465
01:20:17,689 --> 01:20:12,150
things apart but in this case I'm

1466
01:20:20,360 --> 01:20:17,699
wondering if maybe the single atoms of

1467
01:20:22,580 --> 01:20:20,370
the atomic gas or in some way being

1468
01:20:25,280 --> 01:20:22,590
compelled to join together and become a

1469
01:20:32,260 --> 01:20:25,290
more secular than what you're trying to

1470
01:20:37,669 --> 01:20:32,270
say okay so okay actually you are you

1471
01:20:40,250 --> 01:20:37,679
you are actually going into the

1472
01:20:44,200 --> 01:20:40,260
direction of feedback feedback is

1473
01:20:47,240 --> 01:20:44,210
another another topic we study a lot

1474
01:20:50,390 --> 01:20:47,250
okay so it's like destroying molecules

1475
01:20:56,620 --> 01:20:50,400
or yeah feedback process destroy

1476
01:21:02,399 --> 01:20:59,060
atoms combine to form molecules so that

1477
01:21:05,430 --> 01:21:02,409
is a different that is a

1478
01:21:07,560 --> 01:21:05,440
and their topic as well and yeah those

1479
01:21:10,229 --> 01:21:07,570
feedback processes for example if there

1480
01:21:12,470 --> 01:21:10,239
is supernova explosion or things like

1481
01:21:16,800 --> 01:21:12,480
that and it might happen and these

1482
01:21:21,870 --> 01:21:16,810
radiation might also break these

1483
01:21:24,030 --> 01:21:21,880
molecules into atoms so yes okay so if

1484
01:21:27,660 --> 01:21:24,040
we have no more questions we have one

1485
01:21:33,060 --> 01:21:27,670
more question just interested in the

1486
01:21:36,479 --> 01:21:33,070
size of the particles on this dust so

1487
01:21:39,780 --> 01:21:36,489
the they are grain so the they are

1488
01:21:44,790 --> 01:21:39,790

angstrom sizes I can say angstrom is 10

1489
01:21:52,590 --> 01:21:44,800
to the power minus 10 meters so and and

1490
01:21:55,860 --> 01:21:52,600
their sizes vary a lot yeah all right so

1491
01:21:58,229 --> 01:21:55,870
if they're no more question it's great

1492
01:22:01,350 --> 01:21:58,239
we will see you all again on February

1493
01:22:04,080 --> 01:22:01,360
4th where this guy Frank Summers will be

1494
01:22:06,780 --> 01:22:04,090
speaking on the crab nebula and things

1495
01:22:08,669 --> 01:22:06,790
that go kaboom in the night I thank you

1496
01:22:10,380 --> 01:22:08,679
all for coming out on this January