How do planetary atmospheres change over time?

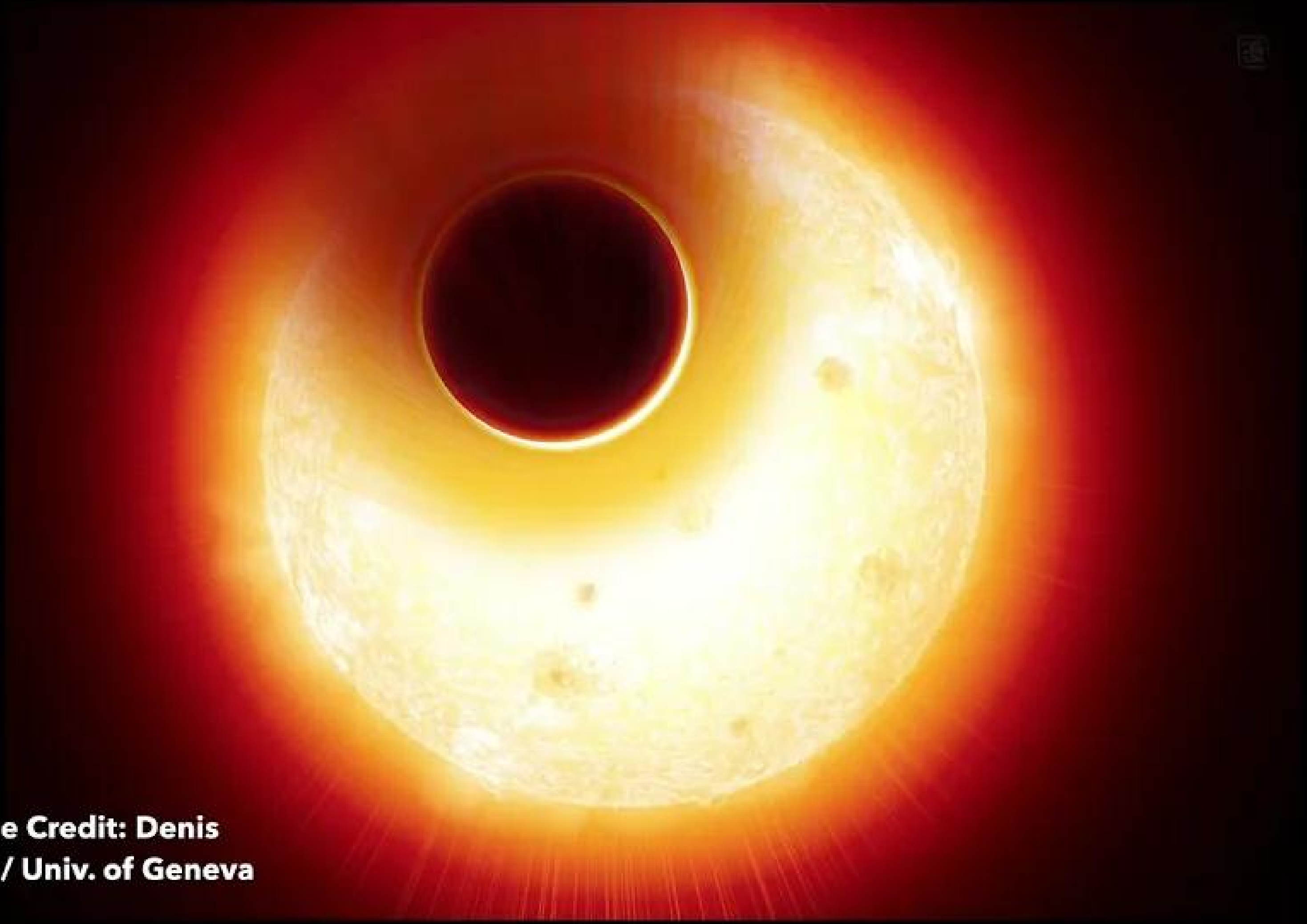

Image Credit: Denis Bajram / Univ. of Geneva

1
00:00:05,030 --> 00:00:02,230
hi everyone my name is chris visa

2
00:00:06,470 --> 00:00:05,040
program and i'm a fifth year phd student

3
00:00:08,150 --> 00:00:06,480
at caltech

4
00:00:10,230 --> 00:00:08,160
and today i'll be talking a little bit

5
00:00:12,789 --> 00:00:10,240
about our project studying the

6
00:00:16,630 --> 00:00:12,799
atmospheric evolution of three young

7
00:00:18,070 --> 00:00:16,640
planets in the v1298 tau system

8
00:00:20,470 --> 00:00:18,080
this is work that i've done with my

9
00:00:22,150 --> 00:00:20,480
advisor heather knudsen along with all

10
00:00:23,830 --> 00:00:22,160
of the collaborators you see on the

11
00:00:25,750 --> 00:00:23,840
screen

12
00:00:27,830 --> 00:00:25,760
first i'm going to be talking about the

13
00:00:29,470 --> 00:00:27,840

evolving atmospheres of young planets

14
00:00:32,069 --> 00:00:29,480
and why this topic might be

15
00:00:33,590 --> 00:00:32,079
astrobiologically relevant

16
00:00:35,430 --> 00:00:33,600
then i'm going to talk about how we

17
00:00:37,510 --> 00:00:35,440
actually make observations of

18
00:00:39,270 --> 00:00:37,520
atmospheric evolution in young planets

19
00:00:42,630 --> 00:00:39,280
and in particular i'll be discussing a

20
00:00:45,190 --> 00:00:42,640
technique called helium photometry

21
00:00:47,990 --> 00:00:45,200
and finally i'll discuss our recent

22
00:00:50,950 --> 00:00:48,000
results applying helium photometry to

23
00:00:52,630 --> 00:00:50,960
the planets in the v1298 tau system and

24
00:00:54,229 --> 00:00:52,640
i'll motivate some future work that i

25
00:00:56,069 --> 00:00:54,239
hope will get done over the next few

26
00:00:57,590 --> 00:00:56,079
years

27
00:00:59,590 --> 00:00:57,600
the fundamental question that we're

28
00:01:03,990 --> 00:00:59,600
trying to answer is how do planetary

29
00:01:08,630 --> 00:01:06,390
to situate ourselves the majority of

30
00:01:10,870 --> 00:01:08,640
extrasolar planets planets orbiting

31
00:01:13,109 --> 00:01:10,880
stars that are not our sun

32
00:01:15,670 --> 00:01:13,119
orbit quite close to their host stars

33
00:01:16,789 --> 00:01:15,680
within an orbital period of 100 days or

34
00:01:18,149 --> 00:01:16,799
so

35
00:01:19,990 --> 00:01:18,159
this means that these planets are

36
00:01:22,550 --> 00:01:20,000
getting constantly bombarded by

37
00:01:25,350 --> 00:01:22,560
high-energy radiation and that can

38
00:01:27,109 --> 00:01:25,360

really change how the planet looks to us

39
00:01:29,270 --> 00:01:27,119
and how the planet evolves over its

40
00:01:31,590 --> 00:01:29,280
lifetime

41
00:01:33,510 --> 00:01:31,600
consider a hydrogen atom living in an

42
00:01:36,149 --> 00:01:33,520
exoplanet atmosphere

43
00:01:37,990 --> 00:01:36,159
because the planet is so irradiated

44
00:01:41,109 --> 00:01:38,000
that hydrogen atom is going to see an

45
00:01:44,630 --> 00:01:41,119
extreme ultraviolet photon with

46
00:01:46,710 --> 00:01:44,640
energy exceeding 13.6 electron volts

47
00:01:49,030 --> 00:01:46,720
quite often

48
00:01:51,910 --> 00:01:49,040
and what that photon can do is it can

49
00:01:56,709 --> 00:01:51,920
ionize the hydrogen atom

50
00:01:59,109 --> 00:01:56,719
but if the photon energy exceeds 13.6 ev

51
00:02:01,030 --> 00:01:59,119
that excess energy has to go somewhere

52
00:02:03,109 --> 00:02:01,040
and it goes into heating

53
00:02:05,270 --> 00:02:03,119
the gas goes into the thermal energy of

54
00:02:07,270 --> 00:02:05,280
the planetary atmosphere

55
00:02:08,790 --> 00:02:07,280
and as this happens many many times

56
00:02:10,229 --> 00:02:08,800
because the planet is severely

57
00:02:12,309 --> 00:02:10,239
irradiated

58
00:02:14,790 --> 00:02:12,319
for many many hydrogen and helium atoms

59
00:02:17,270 --> 00:02:14,800
in the planetary atmosphere

60
00:02:19,990 --> 00:02:17,280
the net effect is the planetary

61
00:02:22,470 --> 00:02:20,000
atmosphere can heat up so much

62
00:02:25,110 --> 00:02:22,480
that it becomes gravitationally unbound

63
00:02:27,670 --> 00:02:25,120

that the planetary atmosphere is just

64
00:02:31,910 --> 00:02:29,430
and we can imagine that this has pretty

65
00:02:35,589 --> 00:02:31,920
important consequences for the planetary

66
00:02:37,589 --> 00:02:35,599
mass as the material is literally being

67
00:02:39,910 --> 00:02:37,599
lost from the system

68
00:02:41,509 --> 00:02:39,920
for the planetary radius as well as i'll

69
00:02:44,070 --> 00:02:41,519
show in a second

70
00:02:45,910 --> 00:02:44,080
and also for habitability the presence

71
00:02:48,470 --> 00:02:45,920
or absence of an atmosphere is known to

72
00:02:50,949 --> 00:02:48,480
be quite astrobiologically relevant and

73
00:02:53,509 --> 00:02:50,959
so understanding the primary factors

74
00:02:56,309 --> 00:02:53,519
that control whether a planet can retain

75
00:02:57,830 --> 00:02:56,319
or whether it loses an atmosphere is of

76
00:03:01,190 --> 00:02:57,840
utmost importance

77
00:03:05,110 --> 00:03:03,110
now to briefly mention one consequence

78
00:03:06,949 --> 00:03:05,120
of atmospheric evolution we can take a

79
00:03:09,830 --> 00:03:06,959
look at the histogram of observed

80
00:03:11,670 --> 00:03:09,840
exoplanet radii from bj fulton's work

81
00:03:13,589 --> 00:03:11,680
done in 2018.

82
00:03:16,710 --> 00:03:13,599
what's being shown here is the average

83
00:03:19,030 --> 00:03:16,720
number of planets per star as a function

84
00:03:21,589 --> 00:03:19,040
of planetary size and i've indicated the

85
00:03:23,030 --> 00:03:21,599
sizes of earth neptune and jupiter for

86
00:03:24,789 --> 00:03:23,040
reference

87
00:03:26,149 --> 00:03:24,799
and while you can see that the most

88
00:03:28,710 --> 00:03:26,159

common type of planet that's been

89
00:03:31,589 --> 00:03:28,720
discovered to date is something between

90
00:03:33,030 --> 00:03:31,599
the size of the earth and neptune

91
00:03:34,630 --> 00:03:33,040
we can see that the distribution is

92
00:03:36,550 --> 00:03:34,640
pretty bimodal

93
00:03:38,630 --> 00:03:36,560
and actually this has a lot to do with

94
00:03:40,869 --> 00:03:38,640
atmospheric evolution we think that

95
00:03:43,270 --> 00:03:40,879
planets on the large side of this radius

96
00:03:45,750 --> 00:03:43,280
gap called subneptunes

97
00:03:48,070 --> 00:03:45,760
at around 2.5 earth radii

98
00:03:49,990 --> 00:03:48,080
we think that these planets retained

99
00:03:52,949 --> 00:03:50,000
most of their atmosphere against the

100
00:03:54,710 --> 00:03:52,959
effects of atmospheric escape

101
00:03:56,229 --> 00:03:54,720
and we think planets on the small side

102
00:03:58,949 --> 00:03:56,239
of the radius gap

103
00:04:00,149 --> 00:03:58,959
at around 1.5 earth radii

104
00:04:01,750 --> 00:04:00,159
we think that they lost their

105
00:04:04,149 --> 00:04:01,760
atmospheres

106
00:04:06,470 --> 00:04:04,159
and so clearly atmospheric evolution has

107
00:04:07,429 --> 00:04:06,480
an outsized impact on how planets appear

108
00:04:09,350 --> 00:04:07,439
to us

109
00:04:11,589 --> 00:04:09,360
and how planets evolve over their

110
00:04:14,070 --> 00:04:11,599
lifetimes

111
00:04:16,550 --> 00:04:14,080
now to understand when this process is

112
00:04:18,629 --> 00:04:16,560
happening over a planet's lifetime it's

113
00:04:20,870 --> 00:04:18,639

necessary to look at the high energy

114
00:04:22,629 --> 00:04:20,880
radiation of the host star

115
00:04:24,469 --> 00:04:22,639
and what's being plotted here is the

116
00:04:27,749 --> 00:04:24,479
x-ray luminosity

117
00:04:28,710 --> 00:04:27,759
of three different stellar models with

118
00:04:30,469 --> 00:04:28,720
different

119
00:04:33,110 --> 00:04:30,479
rotation rates

120
00:04:35,990 --> 00:04:33,120
as a function of stellar age and you can

121
00:04:38,390 --> 00:04:36,000
see that for all three models the star

122
00:04:40,710 --> 00:04:38,400
is outputting much more x-ray luminosity

123
00:04:42,390 --> 00:04:40,720
over the first 100 million years or so

124
00:04:44,469 --> 00:04:42,400
of its life

125
00:04:46,230 --> 00:04:44,479
and what that leads us to conclude is

126
00:04:48,550 --> 00:04:46,240
that we should try to observe

127
00:04:51,430 --> 00:04:48,560
atmospheric escape when it's happening

128
00:04:54,150 --> 00:04:51,440
to planets that are less than around 100

129
00:04:56,710 --> 00:04:54,160
million years old or so

130
00:04:58,629 --> 00:04:56,720
now the problem is that most planets

131
00:05:00,950 --> 00:04:58,639
that have ever been discovered

132
00:05:03,830 --> 00:05:00,960
are about a gig a year or older most of

133
00:05:05,510 --> 00:05:03,840
these planets are positively ancient

134
00:05:08,310 --> 00:05:05,520
compared to the time scales on which

135
00:05:10,070 --> 00:05:08,320
atmospheric escape happens

136
00:05:11,590 --> 00:05:10,080
so the problem is we've never observed

137
00:05:13,430 --> 00:05:11,600
how the atmospheres of young planets

138
00:05:14,790 --> 00:05:13,440

evolved before

139
00:05:16,790 --> 00:05:14,800
and this really prevents us from

140
00:05:18,629 --> 00:05:16,800
answering the question how efficiently

141
00:05:19,430 --> 00:05:18,639
can young planets turn radiation into

142
00:05:21,590 --> 00:05:19,440
heat

143
00:05:24,469 --> 00:05:21,600
this is the primary control on whether a

144
00:05:26,469 --> 00:05:24,479
planet keeps or loses its atmosphere and

145
00:05:29,749 --> 00:05:26,479
so this quantity is of utmost

146
00:05:31,830 --> 00:05:29,759
astrobiological relevance

147
00:05:35,350 --> 00:05:31,840
to remedy this we looked at the young

148
00:05:37,510 --> 00:05:35,360
transiting system v1298 tau

149
00:05:38,870 --> 00:05:37,520
which was discovered by trevor david in

150
00:05:40,870 --> 00:05:38,880
2019

151
00:05:42,870 --> 00:05:40,880
now i'll clarify what transiting means

152
00:05:44,469 --> 00:05:42,880
in a second but basically it just means

153
00:05:46,390 --> 00:05:44,479
that the planets pass in front of the

154
00:05:48,710 --> 00:05:46,400
host star with respect to our line of

155
00:05:51,110 --> 00:05:48,720
sight

156
00:05:53,110 --> 00:05:51,120
now this system is 23 million years old

157
00:05:57,350 --> 00:05:53,120
so it's young enough for us to observe

158
00:05:58,790 --> 00:05:57,360
atmospheric escape occurring in action

159
00:06:01,430 --> 00:05:58,800
there are three known planets in the

160
00:06:03,510 --> 00:06:01,440
system planet c with orbital period 8

161
00:06:04,950 --> 00:06:03,520
days and a size about half that of

162
00:06:07,670 --> 00:06:04,960
jupiter

163
00:06:10,870 --> 00:06:07,680

planet d with orbital period 12 days and

164
00:06:13,510 --> 00:06:10,880
a little bit larger than planet c

165
00:06:17,189 --> 00:06:13,520
and then planet b with orbital period 24

166
00:06:19,350 --> 00:06:17,199
days and a size about that of jupiter

167
00:06:21,670 --> 00:06:19,360
so now that we've selected a target we

168
00:06:24,230 --> 00:06:21,680
can ask how do we observe atmospheric

169
00:06:26,230 --> 00:06:24,240
escape in action

170
00:06:28,550 --> 00:06:26,240
one way to do this is with a technique

171
00:06:30,390 --> 00:06:28,560
called transit spectroscopy

172
00:06:31,990 --> 00:06:30,400
so in the transit method we're watching

173
00:06:34,550 --> 00:06:32,000
planets as they pass in front of their

174
00:06:36,070 --> 00:06:34,560
host stars and block out a little bit of

175
00:06:38,790 --> 00:06:36,080
the star's light

176
00:06:40,629 --> 00:06:38,800
and larger planets block out

177
00:06:42,710 --> 00:06:40,639
proportionally more light from the host

178
00:06:44,629 --> 00:06:42,720
star

179
00:06:47,029 --> 00:06:44,639
now we can visualize this diagram in

180
00:06:50,070 --> 00:06:47,039
this very not to scale cartoon shown

181
00:06:52,150 --> 00:06:50,080
here and again some light from the host

182
00:06:54,150 --> 00:06:52,160
star will be blocked by the planet and

183
00:06:56,309 --> 00:06:54,160
won't reach your telescope

184
00:06:58,150 --> 00:06:56,319
during a transit i should say but some

185
00:07:01,029 --> 00:06:58,160
of the light will reach your telescope

186
00:07:02,950 --> 00:07:01,039
and this is kind of the nominal case

187
00:07:05,189 --> 00:07:02,960
however when a planet's atmosphere is

188
00:07:06,710 --> 00:07:05,199

escaping some of that light is actually

189
00:07:09,110 --> 00:07:06,720
getting filtered through that low

190
00:07:11,110 --> 00:07:09,120
density escaping atmosphere

191
00:07:13,270 --> 00:07:11,120
and if we can choose

192
00:07:16,309 --> 00:07:13,280
to observe at a wavelength where that

193
00:07:18,550 --> 00:07:16,319
low density tenuous gas becomes opaque

194
00:07:20,870 --> 00:07:18,560
then suddenly the planet

195
00:07:23,430 --> 00:07:20,880
will absorb it'll block out much more

196
00:07:25,029 --> 00:07:23,440
light and the planet will appear much

197
00:07:27,029 --> 00:07:25,039
larger to us

198
00:07:28,870 --> 00:07:27,039
so now we'll quickly describe how we

199
00:07:31,430 --> 00:07:28,880
make these measurements in practice uh

200
00:07:34,070 --> 00:07:31,440
with helium photometry

201
00:07:35,670 --> 00:07:34,080
so our experimental experimental design

202
00:07:38,150 --> 00:07:35,680
is pretty simple

203
00:07:39,990 --> 00:07:38,160
we take light from the telescope we pass

204
00:07:42,309 --> 00:07:40,000
it through an optical element called an

205
00:07:44,469 --> 00:07:42,319
engineered diffuser which just helps us

206
00:07:46,070 --> 00:07:44,479
control systematics

207
00:07:48,629 --> 00:07:46,080
that light then goes through an ultra

208
00:07:52,390 --> 00:07:48,639
narrow bandpass filter that is centered

209
00:07:54,390 --> 00:07:52,400
on that 1080 1083 nanometer line

210
00:07:56,150 --> 00:07:54,400
uh and then it forms our image where we

211
00:07:57,990 --> 00:07:56,160
can take a picture much like you would

212
00:08:00,469 --> 00:07:58,000
take a picture with your iphone camera

213
00:08:02,469 --> 00:08:00,479

except that we take it in the infrared

214
00:08:03,909 --> 00:08:02,479
and we take many many many pictures over

215
00:08:06,390 --> 00:08:03,919
the course of a night

216
00:08:09,990 --> 00:08:06,400
and we track the star's brightness in

217
00:08:12,390 --> 00:08:10,000
all those pictures to form a light curve

218
00:08:14,629 --> 00:08:12,400
and based on how much light gets blocked

219
00:08:16,950 --> 00:08:14,639
out during the planetary transit we can

220
00:08:19,110 --> 00:08:16,960
tell whether or not helium absorption is

221
00:08:21,510 --> 00:08:19,120
going on in the planetary atmosphere and

222
00:08:24,710 --> 00:08:21,520
in so doing we can tell how quickly that

223
00:08:28,309 --> 00:08:26,790
so here's an example of a measurement we

224
00:08:33,110 --> 00:08:28,319
made when we were commissioning this

225
00:08:36,389 --> 00:08:33,120
observing mode of the planet wasp 69b

226
00:08:38,630 --> 00:08:36,399
now this planet when observed at other

227
00:08:41,829 --> 00:08:38,640
less special wavelengths

228
00:08:43,829 --> 00:08:41,839
looks like this in the blue

229
00:08:45,990 --> 00:08:43,839
what's being shown here is the star's

230
00:08:47,350 --> 00:08:46,000
brightness over time and you can see

231
00:08:49,110 --> 00:08:47,360
that the planet

232
00:08:50,710 --> 00:08:49,120
at the transit center is blocking out a

233
00:08:52,790 --> 00:08:50,720
little less than two percent of the

234
00:08:55,269 --> 00:08:52,800
star's light

235
00:08:57,829 --> 00:08:55,279
however when we measured it at 1083

236
00:09:00,230 --> 00:08:57,839
nanometers we got the data in gray

237
00:09:03,110 --> 00:09:00,240
which are binned in black and shown with

238
00:09:05,829 --> 00:09:03,120

our best fit model in red

239
00:09:08,150 --> 00:09:05,839
and clearly at 1083 nanometers the

240
00:09:10,630 --> 00:09:08,160
planet blocks out more than two percent

241
00:09:12,630 --> 00:09:10,640
of the star's light

242
00:09:14,790 --> 00:09:12,640
and so we use this measurement to

243
00:09:18,550 --> 00:09:14,800
confirm the presence of helium in the

244
00:09:19,910 --> 00:09:18,560
atmosphere of wasp 69b at 10.1 sigma

245
00:09:20,630 --> 00:09:19,920
confidence

246
00:09:22,710 --> 00:09:20,640
now

247
00:09:24,389 --> 00:09:22,720
this system is pretty old so it doesn't

248
00:09:26,310 --> 00:09:24,399
tell us about what's going on when

249
00:09:28,230 --> 00:09:26,320
atmospheric escape is most important for

250
00:09:30,230 --> 00:09:28,240
a planet's life but it helped us

251
00:09:32,630 --> 00:09:30,240
understand how our instrument worked and

252
00:09:37,269 --> 00:09:32,640
it helped us confirm that everything was

253
00:09:41,829 --> 00:09:39,670
so in this work we applied this

254
00:09:44,070 --> 00:09:41,839
technique to the planets in the v1298

255
00:09:46,710 --> 00:09:44,080
tau system and now we'll describe some

256
00:09:49,190 --> 00:09:46,720
of the results that we saw

257
00:09:51,990 --> 00:09:49,200
when we looked at the transit of v1298

258
00:09:53,110 --> 00:09:52,000
tau c we weren't able to detect anything

259
00:09:54,949 --> 00:09:53,120
at all

260
00:09:56,790 --> 00:09:54,959
our light curve is shown on the left

261
00:09:59,030 --> 00:09:56,800
with data in gray

262
00:10:02,230 --> 00:09:59,040
uh bend in black

263
00:10:04,710 --> 00:10:02,240

with a best fit model in the solid line

264
00:10:07,350 --> 00:10:04,720
and the model for the transit at

265
00:10:09,269 --> 00:10:07,360
non 1093 nanometer wavelengths in the

266
00:10:11,030 --> 00:10:09,279
dashed line and i've also shown a

267
00:10:12,949 --> 00:10:11,040
baseline model for

268
00:10:15,509 --> 00:10:12,959
just showing how the star and the

269
00:10:16,949 --> 00:10:15,519
weather evolve over the night

270
00:10:19,509 --> 00:10:16,959
uh in red

271
00:10:21,509 --> 00:10:19,519
and you can see that the model the solid

272
00:10:24,470 --> 00:10:21,519
line doesn't really indicate that we

273
00:10:26,150 --> 00:10:24,480
detected transit at any confidence

274
00:10:28,310 --> 00:10:26,160
this is kind of disappointing and it's

275
00:10:30,230 --> 00:10:28,320
probably due to poor weather which you

276
00:10:31,829 --> 00:10:30,240
know sometimes you get unlucky

277
00:10:33,590 --> 00:10:31,839
but at the same time we can definitely

278
00:10:35,590 --> 00:10:33,600
rule out a very large transit in the

279
00:10:38,630 --> 00:10:35,600
helium line which is an important result

280
00:10:43,110 --> 00:10:40,389
when we looked at planet b i've shown

281
00:10:45,030 --> 00:10:43,120
the same thing for planet b on the right

282
00:10:47,350 --> 00:10:45,040
we did detect the planet

283
00:10:49,350 --> 00:10:47,360
uh the transit of this planet

284
00:10:51,030 --> 00:10:49,360
but we don't think we detected any clear

285
00:10:53,509 --> 00:10:51,040
helium absorption

286
00:10:56,150 --> 00:10:53,519
our best fit model is shown

287
00:10:58,069 --> 00:10:56,160
on the right in the solid green line and

288
00:11:01,509 --> 00:10:58,079

the dash green line shows the best fit

289
00:11:03,190 --> 00:11:01,519
model at non 1083 nanometer wavelengths

290
00:11:05,030 --> 00:11:03,200
and you can see that the models kind of

291
00:11:07,269 --> 00:11:05,040
overly each other they have slightly

292
00:11:09,509 --> 00:11:07,279
different shapes but they're not really

293
00:11:11,030 --> 00:11:09,519
distinguishable in any statistically

294
00:11:13,030 --> 00:11:11,040
significant way

295
00:11:14,550 --> 00:11:13,040
so a larger transit in the helium line

296
00:11:16,310 --> 00:11:14,560
is still possible but we would

297
00:11:17,670 --> 00:11:16,320
definitely need more data to confirm

298
00:11:19,750 --> 00:11:17,680
that

299
00:11:21,910 --> 00:11:19,760
now when we looked at planet d we think

300
00:11:24,150 --> 00:11:21,920
we see a tentative detection

301
00:11:25,910 --> 00:11:24,160
now we took two knights of data on this

302
00:11:27,509 --> 00:11:25,920
planet which are shown with the circles

303
00:11:28,470 --> 00:11:27,519
and triangles in the light curve on the

304
00:11:30,310 --> 00:11:28,480
left

305
00:11:32,150 --> 00:11:30,320
and the signal appears consistent in

306
00:11:34,870 --> 00:11:32,160
amplitude across both knights of data

307
00:11:36,470 --> 00:11:34,880
collection which is really exciting

308
00:11:38,310 --> 00:11:36,480
however

309
00:11:40,470 --> 00:11:38,320
to stitch this light curve together we

310
00:11:42,150 --> 00:11:40,480
did require a transit timing offset

311
00:11:44,550 --> 00:11:42,160
which is the slight deviation from a

312
00:11:46,870 --> 00:11:44,560
keplerian orbit and that was enough to

313
00:11:48,389 --> 00:11:46,880

make us a bit hesitant about the result

314
00:11:50,949 --> 00:11:48,399
and so we're calling it a tentative

315
00:11:52,870 --> 00:11:50,959
detection rather than a slam dunk

316
00:11:54,310 --> 00:11:52,880
still it's a really interesting result

317
00:11:56,870 --> 00:11:54,320
and it means that this planet should be

318
00:11:58,629 --> 00:11:56,880
prioritized for future follow-up

319
00:12:00,790 --> 00:11:58,639
to summarize our work

320
00:12:02,710 --> 00:12:00,800
we are attempting to measure atmospheric

321
00:12:03,509 --> 00:12:02,720
escape from young planets for the first

322
00:12:05,670 --> 00:12:03,519
time

323
00:12:08,230 --> 00:12:05,680
and here's a graphic of the geometry of

324
00:12:10,310 --> 00:12:08,240
what we're actually measuring

325
00:12:12,710 --> 00:12:10,320
now we tentatively detect helium

326
00:12:14,470 --> 00:12:12,720
absorption for v1298 tau d

327
00:12:16,389 --> 00:12:14,480
which indicates that this might be the

328
00:12:19,269 --> 00:12:16,399
first known young planet with

329
00:12:21,110 --> 00:12:19,279
observationally accessible mass loss and

330
00:12:23,509 --> 00:12:21,120
in the future we'd of course like to get

331
00:12:25,509 --> 00:12:23,519
more data which uh we'll be hopefully

332
00:12:27,750 --> 00:12:25,519
gathering some more full transits in the

333
00:12:29,030 --> 00:12:27,760
winter weather permitting

334
00:12:31,030 --> 00:12:29,040
and we'd also like to measure the

335
00:12:32,710 --> 00:12:31,040
planetary masses to know the

336
00:12:34,470 --> 00:12:32,720
gravitational potentials from which

337
00:12:35,670 --> 00:12:34,480
these planets atmospheres may be

338
00:12:37,430 --> 00:12:35,680

escaping