ATMOSPHERIC DYNAMICS & ESCAPE: INSIGHTS FROM HE I 1083 NM OBSERVATIONS

ANTONIJA OKLOPCIC

1
00:00:08,220 --> 00:00:06,590
[Music]

2
00:00:09,570 --> 00:00:08,230
hello everyone

3
00:00:11,640 --> 00:00:09,580
first I would like to start by thanking

4
00:00:15,330 --> 00:00:11,650
the organizers for the opportunity to

5
00:00:17,340 --> 00:00:15,340
give this talk so as we said today I

6
00:00:20,249 --> 00:00:17,350
will be talking about what we can learn

7
00:00:22,470 --> 00:00:20,259
about atmospheric dynamics especially in

8
00:00:25,409 --> 00:00:22,480
the upper exoplanet atmospheres and as a

9
00:00:28,460 --> 00:00:25,419
result as a result of that of what we

10
00:00:31,229 --> 00:00:28,470
can learn about atmospheric escape by

11
00:00:33,510 --> 00:00:31,239
looking at transit observing transits of

12
00:00:40,260 --> 00:00:33,520
exoplanets in one particular line of

13
00:00:44,600 --> 00:00:40,270

helium around 1 micron so j/o a little

14
00:00:46,950 --> 00:00:44,610
bit messed up ok James gave a beautiful

15
00:00:48,390 --> 00:00:46,960
overview of this entire topic and he

16
00:00:51,090 --> 00:00:48,400
saved me a lot of work so basically I

17
00:00:53,190 --> 00:00:51,100
can skip my entire introduction so he

18
00:00:54,870 --> 00:00:53,200
introduced hydrodynamic escaping close

19
00:00:57,720 --> 00:00:54,880
and exoplanets all just quickly

20
00:01:00,210 --> 00:00:57,730
reiterate these highly radiated planets

21
00:01:02,130 --> 00:01:00,220
planets absorbed a lot of high-energy

22
00:01:04,350 --> 00:01:02,140
radiation their atmospheres get heated

23
00:01:07,080 --> 00:01:04,360
up and as a result they have this radial

24
00:01:09,840 --> 00:01:07,090
outflows that can be very efficient at

25
00:01:11,999 --> 00:01:09,850
removing gas from planets and this can

26
00:01:14,310 --> 00:01:12,009
have important consequences for the

27
00:01:18,510 --> 00:01:14,320
demographics of exoplanets that we

28
00:01:22,980 --> 00:01:18,520
observe for this sub Jupiter desert and

29
00:01:25,309 --> 00:01:22,990
this radius Valley so one way to create

30
00:01:28,380 --> 00:01:25,319
these features is to atmospheric escape

31
00:01:30,149 --> 00:01:28,390
but also as James pointed out there are

32
00:01:32,099 --> 00:01:30,159
a lot of things we don't understand yet

33
00:01:35,160 --> 00:01:32,109
about atmospheric escape and a lot of

34
00:01:39,059 --> 00:01:35,170
that is because we can have not observed

35
00:01:39,989 --> 00:01:39,069
it in action until now in large samples

36
00:01:41,789 --> 00:01:39,999
of exoplanet

37
00:01:44,309 --> 00:01:41,799
so things like how does exactly mass

38
00:01:46,739 --> 00:01:44,319

flow rate depend on various properties

39
00:01:48,870 --> 00:01:46,749
of the planet and its host star so mass

40
00:01:52,379 --> 00:01:48,880
radius incident walks at different

41
00:01:54,599 --> 00:01:52,389
wavelengths age spectral type so on what

42
00:01:57,769 --> 00:01:54,609
is that heating efficiency

43
00:01:59,879 --> 00:01:57,779
maybe we can empirically derive it and

44
00:02:02,069 --> 00:01:59,889
see how it compared star through

45
00:02:03,749 --> 00:02:02,079
theoretical expectations then how

46
00:02:06,719 --> 00:02:03,759
important there are other non-thermal

47
00:02:10,050 --> 00:02:06,729
mechanisms of atmospheric escapes and

48
00:02:12,149 --> 00:02:10,060
then of course the what role do magnetic

49
00:02:14,789 --> 00:02:12,159
fields or stellar winds play in this

50
00:02:15,540 --> 00:02:14,799
entire picture so basically I think that

51
00:02:17,460 --> 00:02:15,550
one

52
00:02:19,190 --> 00:02:17,470
really good way to start answering all

53
00:02:21,630 --> 00:02:19,200
these questions is by observing

54
00:02:26,070 --> 00:02:21,640
atmospheric escape in action as it

55
00:02:28,650 --> 00:02:26,080
happens and to do that the best place to

56
00:02:30,540 --> 00:02:28,660
look are these uppermost layers of

57
00:02:33,420 --> 00:02:30,550
planetary atmosphere so we're talking

58
00:02:38,850 --> 00:02:33,430
about really really far out somewhere

59
00:02:41,670 --> 00:02:38,860
around few planetary radii regions so

60
00:02:44,940 --> 00:02:41,680
basically around the Roche radius of the

61
00:02:46,500 --> 00:02:44,950
planet or even maybe beyond and these

62
00:02:48,300 --> 00:02:46,510
are really really low density

63
00:02:50,730 --> 00:02:48,310

environments so in order to observe

64
00:02:53,280 --> 00:02:50,740
these regions in transit you have to

65
00:02:55,340 --> 00:02:53,290
look at very specific wavelength so

66
00:02:58,740 --> 00:02:55,350
perform transition spectroscopy at

67
00:03:00,330 --> 00:02:58,750
wavelengths such as lyman-alpha as also

68
00:03:04,110 --> 00:03:00,340
James mentioned and show this figure

69
00:03:06,960 --> 00:03:04,120
already so this has been done basically

70
00:03:10,890 --> 00:03:06,970
in the last 15 years since this papers

71
00:03:13,980 --> 00:03:10,900
in 2003 2004 lyman-alpha transits have

72
00:03:16,230 --> 00:03:13,990
been observed in exactly four planets in

73
00:03:18,800 --> 00:03:16,240
these 15 years and this just tells you

74
00:03:22,500 --> 00:03:18,810
how difficult these measurements are

75
00:03:24,800 --> 00:03:22,510
because stars are most like the planet

76
00:03:27,479 --> 00:03:24,810
hosting stars are intrinsically bright

77
00:03:30,060 --> 00:03:27,489
intrinsically very faint at these

78
00:03:32,280 --> 00:03:30,070
wavelengths and we lose a lot of also

79
00:03:34,890 --> 00:03:32,290
information in the central part of the

80
00:03:38,490 --> 00:03:34,900
lyman-alpha due to the I am absorption

81
00:03:40,710 --> 00:03:38,500
so we've seen this picture before from

82
00:03:46,290 --> 00:03:40,720
Ehrenreich at all 2015 it's the

83
00:03:49,020 --> 00:03:46,300
lyman-alpha flux of GJ 436b black is out

84
00:03:51,750 --> 00:03:49,030
of transit and in red is in transit and

85
00:03:54,600 --> 00:03:51,760
even just by eye we see this enormous

86
00:03:57,540 --> 00:03:54,610
drop in flux due to this highly extended

87
00:04:01,680 --> 00:03:57,550
cloud of hydrogen that's surrounding GJ

88
00:04:04,320 --> 00:04:01,690

436b so these observations have been

89
00:04:08,130 --> 00:04:04,330
great because they were first evidence

90
00:04:10,080 --> 00:04:08,140
of the fact that this hydrogen envelopes

91
00:04:13,590 --> 00:04:10,090
can extend very very far out from the

92
00:04:15,540 --> 00:04:13,600
planet where this gas is clearly no

93
00:04:18,000 --> 00:04:15,550
longer bound to the planet so this is

94
00:04:20,670 --> 00:04:18,010
direct evidence of atmospheric escape

95
00:04:22,560 --> 00:04:20,680
but as I mentioned there's a lot of

96
00:04:26,730 --> 00:04:22,570
observational challenges with observing

97
00:04:28,380 --> 00:04:26,740
lyman-alpha and some of it is that we

98
00:04:29,420 --> 00:04:28,390
actually cannot observe the center of

99
00:04:31,460 --> 00:04:29,430
the line where

100
00:04:32,990 --> 00:04:31,470
lot of really interesting information is

101
00:04:35,600 --> 00:04:33,000
contained because basically in

102
00:04:38,780 --> 00:04:35,610
lyman-alpha we mostly see just this high

103
00:04:41,540 --> 00:04:38,790
velocity high velocity tail of the

104
00:04:43,130 --> 00:04:41,550
distribution so we see particles very

105
00:04:45,440 --> 00:04:43,140
far out from the planet that have been

106
00:04:48,230 --> 00:04:45,450
accelerated to the large velocities but

107
00:04:50,510 --> 00:04:48,240
we don't really see what goes on closer

108
00:04:52,730 --> 00:04:50,520
to the planet where these winds and now

109
00:04:54,950 --> 00:04:52,740
flows are actually generated and where a

110
00:04:57,010 --> 00:04:54,960
lot of interesting physics goes on that

111
00:04:59,900 --> 00:04:57,020
we would like to understand better so

112
00:05:03,140 --> 00:04:59,910
this is my main challenge with

113
00:05:05,270 --> 00:05:03,150

lyman-alpha and so we could start

114
00:05:07,670 --> 00:05:05,280
thinking so okay what are the other lore

115
00:05:10,250 --> 00:05:07,680
some other lines that we could use to

116
00:05:12,560 --> 00:05:10,260
make these observations and learn more

117
00:05:15,410 --> 00:05:12,570
about opera exoplanet atmospheres and

118
00:05:17,360 --> 00:05:15,420
Atmospheric escape so there are a few

119
00:05:21,950 --> 00:05:17,370
requirements that we would like our line

120
00:05:24,500 --> 00:05:21,960
to satisfy so first of all one necessary

121
00:05:27,200 --> 00:05:24,510
criterion is it needs to be sensitive to

122
00:05:29,660 --> 00:05:27,210
low density gap because we really want

123
00:05:33,050 --> 00:05:29,670
to know what goes on very far out from

124
00:05:35,480 --> 00:05:33,060
the planet but at the same time we don't

125
00:05:37,640 --> 00:05:35,490
want a line that's also very sensitive

126
00:05:39,350 --> 00:05:37,650
to ISO absorption so we want something

127
00:05:41,810 --> 00:05:39,360
that is very sensitive to low density

128
00:05:45,110 --> 00:05:41,820
gas but not so much that it gets

129
00:05:48,170 --> 00:05:45,120
basically eaten away by is M on its way

130
00:05:49,610 --> 00:05:48,180
towards us and another requirement it

131
00:05:51,100 --> 00:05:49,620
would be really nice if it was

132
00:05:53,690 --> 00:05:51,110
observable from the ground

133
00:05:55,270 --> 00:05:53,700
unlike lyman-alpha which can only be

134
00:05:58,670 --> 00:05:55,280
observed with the Hubble Space Telescope

135
00:06:01,070 --> 00:05:58,680
basically now because then we have many

136
00:06:03,650 --> 00:06:01,080
more telescopes available to us and we

137
00:06:06,470 --> 00:06:03,660
can observe much larger samples of

138
00:06:08,720 --> 00:06:06,480

planets and learn a lot more and it

139
00:06:11,120 --> 00:06:08,730
turns out there is at least one line and

140
00:06:13,160 --> 00:06:11,130
hopefully more of them that satisfies

141
00:06:16,270 --> 00:06:13,170
all of these conditions and that is the

142
00:06:18,650 --> 00:06:16,280
helium line at 1083 nanometers so

143
00:06:20,690 --> 00:06:18,660
actually the origin of this line is

144
00:06:23,630 --> 00:06:20,700
really really interesting from just the

145
00:06:25,970 --> 00:06:23,640
atomic physics point of view so it comes

146
00:06:28,910 --> 00:06:25,980
to the fact that helium atoms can exist

147
00:06:31,310 --> 00:06:28,920
in two configurations based on the

148
00:06:33,200 --> 00:06:31,320
relative orientation of spin of its two

149
00:06:34,850 --> 00:06:33,210
electrons so if the spins are

150
00:06:36,620 --> 00:06:34,860
anti-parallel we're talking about the

151
00:06:39,230 --> 00:06:36,630
single end configuration if they're

152
00:06:41,650 --> 00:06:39,240
parallel we have a triplet configuration

153
00:06:42,980 --> 00:06:41,660
and these two configurations basically

154
00:06:43,910 --> 00:06:42,990
live in the

155
00:06:46,340 --> 00:06:43,920
and looking of each other because

156
00:06:48,050 --> 00:06:46,350
they're not radiatively they're

157
00:06:50,960 --> 00:06:48,060
radiatively be coupled they're still

158
00:06:52,910 --> 00:06:50,970
collisional II am Adams in transition

159
00:06:55,840 --> 00:06:52,920
between a singlet and triplet but

160
00:06:59,840 --> 00:06:55,850
radiative transitions are expressed

161
00:07:03,020 --> 00:06:59,850
which means that the lowest lying state

162
00:07:06,860 --> 00:07:03,030
of the triplet helium which is shown

163
00:07:09,020 --> 00:07:06,870

here is which is very oddly decoupled

164
00:07:11,750 --> 00:07:09,030
from the ground state has an extremely

165
00:07:13,880 --> 00:07:11,760
long lifetime and is metastable and if

166
00:07:15,620 --> 00:07:13,890
you basically look think of triplet

167
00:07:18,350 --> 00:07:15,630
helium you can almost think of it as a

168
00:07:21,020 --> 00:07:18,360
separate species and this would be it's

169
00:07:23,390 --> 00:07:21,030
in a ground state so so-called ground

170
00:07:26,180 --> 00:07:23,400
state of triple of helium and because

171
00:07:28,340 --> 00:07:26,190
it's so high up it's basically 20

172
00:07:32,390 --> 00:07:28,350
electron volts higher than the ground

173
00:07:34,910 --> 00:07:32,400
state all these transitions happen in

174
00:07:37,490 --> 00:07:34,920
either visible or near-infrared which is

175
00:07:39,440 --> 00:07:37,500
really convenient for serving them from

176
00:07:41,690 --> 00:07:39,450
the ground whereas transitions from the

177
00:07:45,680 --> 00:07:41,700
actual ground state of helium are all

178
00:07:47,330 --> 00:07:45,690
the way in the extreme UV and the

179
00:07:50,090 --> 00:07:47,340
basically the strongest transition

180
00:07:51,980 --> 00:07:50,100
originating from this metastable state

181
00:07:54,980 --> 00:07:51,990
is this one and it has the wavelength of

182
00:07:57,730 --> 00:07:54,990
1080 3 nanometers and this line has been

183
00:08:00,920 --> 00:07:57,740
well known and studied in astronomy in

184
00:08:03,200 --> 00:08:00,930
in studies of the Sun of stars and

185
00:08:05,450 --> 00:08:03,210
stellar winds in the studies of Aegean

186
00:08:07,910 --> 00:08:05,460
outflows and it has even been suggested

187
00:08:14,090 --> 00:08:07,920
as a good program exoplanet atmospheres

188
00:08:15,770 --> 00:08:14,100

in 2000 by figure in Sackville but until

189
00:08:18,290 --> 00:08:15,780
recently that has not been a lot of work

190
00:08:21,380 --> 00:08:18,300
done on it so when I started working on

191
00:08:23,210 --> 00:08:21,390
this topic basically the only paper that

192
00:08:25,970 --> 00:08:23,220
I could find in the literature that

193
00:08:27,860 --> 00:08:25,980
discusses actually the talks about an

194
00:08:30,530 --> 00:08:27,870
attempt to observe this line was this

195
00:08:34,460 --> 00:08:30,540
paper from 2003 that reported a non

196
00:08:36,860 --> 00:08:34,470
detection and after that almost as if

197
00:08:39,650 --> 00:08:36,870
the line has been forgotten until

198
00:08:42,770 --> 00:08:39,660
recently so basically what I was

199
00:08:45,620 --> 00:08:42,780
interested in is trying to see how much

200
00:08:49,100 --> 00:08:45,630
absorption in this line can we expect

201
00:08:50,420 --> 00:08:49,110
from these uppermost layers of exoplanet

202
00:08:52,700 --> 00:08:50,430
atmosphere so the thermosphere and

203
00:08:54,710 --> 00:08:52,710
exosphere and it's important to keep in

204
00:08:55,400 --> 00:08:54,720
mind that the conditions in these parts

205
00:08:57,590 --> 00:08:55,410
are very

206
00:09:00,319 --> 00:08:57,600
very different than conditions in lower

207
00:09:01,369 --> 00:09:00,329
regions of atmosphere which most people

208
00:09:03,619 --> 00:09:01,379
think about when they talk about

209
00:09:05,360 --> 00:09:03,629
exoplanet atmosphere so in thermo

210
00:09:08,030 --> 00:09:05,370
spheres we talk about really low

211
00:09:10,970 --> 00:09:08,040
densities and temperatures of 100,000

212
00:09:14,809 --> 00:09:10,980
even 10,000 degrees and this because of

213
00:09:16,639 --> 00:09:14,819

its so low density the population of

214
00:09:18,199 --> 00:09:16,649
atomic levels it's not in local

215
00:09:20,179 --> 00:09:18,209
hydrodynamic equilibrium

216
00:09:22,100 --> 00:09:20,189
so you basically need to do a non LCE

217
00:09:25,069 --> 00:09:22,110
radiative transfer to actually compute

218
00:09:28,429 --> 00:09:25,079
the population level of that metastable

219
00:09:31,179 --> 00:09:28,439
helium so basically I decided to do that

220
00:09:34,100 --> 00:09:31,189
and first I assumed a simple atmospheric

221
00:09:36,470 --> 00:09:34,110
model based on isothermal Parker wind

222
00:09:39,019 --> 00:09:36,480
which is a model that was developed back

223
00:09:40,879 --> 00:09:39,029
in the 50s to describe solar wind but

224
00:09:42,740 --> 00:09:40,889
now we believe it's actually really good

225
00:09:45,590 --> 00:09:42,750
approximation for these planetary

226
00:09:47,860 --> 00:09:45,600
outflows so basically the density

227
00:09:49,670 --> 00:09:47,870
profile looks like this it starts off a

228
00:09:52,009 --> 00:09:49,680
fairly similar to a hydrostatic

229
00:09:55,639 --> 00:09:52,019
atmosphere and evenning drops off faster

230
00:09:59,900 --> 00:09:55,649
and the Velata static atmosphere has a

231
00:10:01,730 --> 00:09:59,910
radial velocity which starts off at very

232
00:10:04,670 --> 00:10:01,740
small values close to the planet and

233
00:10:11,689 --> 00:10:04,680
then at sonic point transitions and

234
00:10:12,590 --> 00:10:11,699
become super sonic and so in in that

235
00:10:15,189 --> 00:10:12,600
kind of environment

236
00:10:17,870 --> 00:10:15,199
alcohol calc I calculated the expected

237
00:10:21,679 --> 00:10:17,880
population level of the metastable

238
00:10:25,129 --> 00:10:21,689

triple helium and found that we can

239
00:10:27,230 --> 00:10:25,139
expect to see these kinds of absorption

240
00:10:29,300 --> 00:10:27,240
signals so even though I keep calling it

241
00:10:31,129 --> 00:10:29,310
the helium line it's actually a triplet

242
00:10:33,620 --> 00:10:31,139
of line which gives us this very

243
00:10:35,900 --> 00:10:33,630
characteristic shape so it has three

244
00:10:38,509 --> 00:10:35,910
lines of these are the wavelengths so

245
00:10:41,299 --> 00:10:38,519
two components are very very close

246
00:10:43,699 --> 00:10:41,309
together and they blend in this red

247
00:10:46,420 --> 00:10:43,709
component or main component and the

248
00:10:48,559 --> 00:10:46,430
third line is further out into the blue

249
00:10:50,420 --> 00:10:48,569
so it has this carrot very

250
00:10:54,999 --> 00:10:50,430
characteristic double double peak

251
00:10:58,249 --> 00:10:55,009
profile so basically as I was finishing

252
00:11:01,189 --> 00:10:58,259
this purely theoretical work completely

253
00:11:04,280 --> 00:11:01,199
independently Jessica's fake who was

254
00:11:06,620 --> 00:11:04,290
who's here actually and she was at that

255
00:11:08,540 --> 00:11:06,630
time a PhD student at the University of

256
00:11:12,560 --> 00:11:08,550
Exeter was looking at

257
00:11:15,829 --> 00:11:12,570
Space Telescope data of what 1:07 be and

258
00:11:18,590 --> 00:11:15,839
she noted that there's this really

259
00:11:21,740 --> 00:11:18,600
strong speak and transit depth around 1

260
00:11:24,880 --> 00:11:21,750
micron and she realized that this could

261
00:11:27,050 --> 00:11:24,890
be due to the this helium line

262
00:11:29,680 --> 00:11:27,060
unfortunately due to the resolution of

263
00:11:32,300 --> 00:11:29,690

Hubble Space Telescope we've see three

264
00:11:34,430 --> 00:11:32,310
the line is not resolved so basically

265
00:11:36,800 --> 00:11:34,440
this entire band says is something like

266
00:11:39,199 --> 00:11:36,810
hundred angstrom whereas if you look at

267
00:11:42,230 --> 00:11:39,209
this line profile the line is maybe one

268
00:11:45,769 --> 00:11:42,240
or two angstrom wide so basically in

269
00:11:47,870 --> 00:11:45,779
this in Hubble Hubble data we cannot

270
00:11:50,150 --> 00:11:47,880
resolve the line but we can still detect

271
00:11:52,790 --> 00:11:50,160
that there's something strongly

272
00:11:54,560 --> 00:11:52,800
absorbing in this entire band path and I

273
00:11:58,040 --> 00:11:54,570
would just like to quickly mention that

274
00:12:00,530 --> 00:11:58,050
Megan Mansfield also observe helium

275
00:12:05,240 --> 00:12:00,540
excess helium absorption in had P 11 in

276
00:12:06,650 --> 00:12:05,250
another Hubble data set so because in

277
00:12:09,610 --> 00:12:06,660
the house in a couple data the line is

278
00:12:12,019 --> 00:12:09,620
unresolved we cannot really tell much

279
00:12:14,180 --> 00:12:12,029
beyond just the equivalent width of the

280
00:12:17,150 --> 00:12:14,190
line and we can't say something about

281
00:12:19,480 --> 00:12:17,160
how this gas is just distributed so this

282
00:12:22,310 --> 00:12:19,490
is another plot from Jessica's paper

283
00:12:25,460 --> 00:12:22,320
that shows how we use two different

284
00:12:27,949 --> 00:12:25,470
models to try to model the signal so one

285
00:12:30,470 --> 00:12:27,959
is the model that I described Parker

286
00:12:32,449 --> 00:12:30,480
when that's fairly spherically symmetric

287
00:12:36,470 --> 00:12:32,459
and it produces this double shaped

288
00:12:39,829 --> 00:12:36,480

profile and another model is by Vincent

289
00:12:42,170 --> 00:12:39,839
Berea that is quite different in

290
00:12:46,850 --> 00:12:42,180
geometry so it has this elongated tail

291
00:12:49,100 --> 00:12:46,860
of material and producers entail in the

292
00:12:51,019 --> 00:12:49,110
absorption feature and with the Hubble

293
00:12:55,310 --> 00:12:51,029
data alone we cannot distinguish between

294
00:12:57,230 --> 00:12:55,320
do these two geometries but luckily the

295
00:13:00,199 --> 00:12:57,240
helium line can be observed from the

296
00:13:02,030 --> 00:13:00,209
ground with many high-resolution

297
00:13:04,220 --> 00:13:02,040
spectrograph and this is not a complete

298
00:13:06,470 --> 00:13:04,230
list and I apologize if I did not

299
00:13:07,759 --> 00:13:06,480
include your favorite spectrograph but

300
00:13:09,920 --> 00:13:07,769
this is just to show that there are many

301
00:13:14,269 --> 00:13:09,930
out there and we can use basically all

302
00:13:16,460 --> 00:13:14,279
of them to look at transit and this have

303
00:13:18,530 --> 00:13:16,470
been done since last year for so and

304
00:13:21,230 --> 00:13:18,540
helium one has been detected a high

305
00:13:22,370 --> 00:13:21,240
spectral resolution in several planets

306
00:13:23,990 --> 00:13:22,380
and this is a

307
00:13:28,100 --> 00:13:24,000
beautiful work done all with the

308
00:13:30,680 --> 00:13:28,110
terminus spectrograph in Spain and so I

309
00:13:33,260 --> 00:13:30,690
would just quickly like to go through a

310
00:13:37,940 --> 00:13:33,270
few really interesting examples so this

311
00:13:40,160 --> 00:13:37,950
is what's 69b and this is worked by Lisa

312
00:13:42,620 --> 00:13:40,170
Northman and please see her posters I

313
00:13:45,740 --> 00:13:42,630

think today so this is a really

314
00:13:48,320 --> 00:13:45,750
interesting an interesting case because

315
00:13:50,540 --> 00:13:48,330
it has it produces about three and a

316
00:13:52,640 --> 00:13:50,550
half almost four percent transient up

317
00:13:57,320 --> 00:13:52,650
transit depth at the center of the

318
00:14:00,890 --> 00:13:57,330
helium line the line I forgot to mention

319
00:14:02,900 --> 00:14:00,900
a big the line ratio between the main

320
00:14:04,520 --> 00:14:02,910
components and the weeks component you

321
00:14:06,620 --> 00:14:04,530
can tell us a lot about the optical

322
00:14:08,870 --> 00:14:06,630
depth of the medium and in this line

323
00:14:11,180 --> 00:14:08,880
it's interesting because it points to an

324
00:14:13,700 --> 00:14:11,190
optically thin atmosphere which we will

325
00:14:16,730 --> 00:14:13,710
see later is not always the case but it

326
00:14:19,220 --> 00:14:16,740
was 69 it is and it's the only one of

327
00:14:22,670 --> 00:14:19,230
the planets observed so far that shows

328
00:14:25,100 --> 00:14:22,680
evidence of a delayed egress compared to

329
00:14:27,470 --> 00:14:25,110
address of the in most other cases the

330
00:14:30,860 --> 00:14:27,480
light curve looks fairly symmetric but

331
00:14:33,380 --> 00:14:30,870
what 69 seems to have a tail of helium

332
00:14:36,200 --> 00:14:33,390
that it takes about 20 minutes longer to

333
00:14:38,030 --> 00:14:36,210
egress than it is when it's in ingress

334
00:14:41,390 --> 00:14:38,040
so it's quite unusual in that sense

335
00:14:45,350 --> 00:14:41,400
that's really interesting another

336
00:14:49,940 --> 00:14:45,360
interesting example at HD 189 73 B we

337
00:14:53,630 --> 00:14:49,950
well-known hot Jupiter it has a smaller

338
00:14:57,500 --> 00:14:53,640

chance of depth of maybe goes up to

339
00:15:00,550 --> 00:14:57,510
about 1% in the align center but this

340
00:15:03,080 --> 00:15:00,560
planet has a really unusual line ratio

341
00:15:04,700 --> 00:15:03,090
the light in the ratio between the main

342
00:15:08,780 --> 00:15:04,710
component and the weak component is

343
00:15:11,060 --> 00:15:08,790
something I think three to one or which

344
00:15:13,960 --> 00:15:11,070
points to a medium of optical depth

345
00:15:18,380 --> 00:15:13,970
around three so it's actually really

346
00:15:20,390 --> 00:15:18,390
dense the signal goes through a dense

347
00:15:23,120 --> 00:15:20,400
medium and optical effect medium which

348
00:15:26,450 --> 00:15:23,130
is quite interesting and different from

349
00:15:28,910 --> 00:15:26,460
what 69b for example and so I hope you

350
00:15:32,170 --> 00:15:28,920
all got a chance on Monday to see you

351
00:15:35,420 --> 00:15:32,180
posters by Gloria and Antoine who

352
00:15:36,140 --> 00:15:35,430
presented the sections of helium in this

353
00:15:38,540 --> 00:15:36,150
planet we

354
00:15:40,940 --> 00:15:38,550
to two different spectrographs on two

355
00:15:43,550 --> 00:15:40,950
different telescopes so this is uh this

356
00:15:48,260 --> 00:15:43,560
is not really being done with multiple

357
00:15:51,050 --> 00:15:48,270
telescopes around the world and to go

358
00:15:53,990 --> 00:15:51,060
back to what 107 B which was that first

359
00:15:56,030 --> 00:15:54,000
detection by Jessica it has been

360
00:15:59,090 --> 00:15:56,040
observed from the ground by a large at

361
00:16:02,990 --> 00:15:59,100
all published just earlier this year and

362
00:16:05,060 --> 00:16:03,000
it still shows the high the highest

363
00:16:07,460 --> 00:16:05,070

chance of depth depth of all the planets

364
00:16:09,350 --> 00:16:07,470
so basically it reaches up to almost

365
00:16:13,480 --> 00:16:09,360
like seven or eight percent in the line

366
00:16:17,510 --> 00:16:13,490
Center so which is quite extraordinary

367
00:16:20,240 --> 00:16:17,520
so we observed also the same planet with

368
00:16:22,100 --> 00:16:20,250
kick with the NIRSPEC spectrograph on

369
00:16:24,800 --> 00:16:22,110
the Keck telescope so this is work done

370
00:16:26,930 --> 00:16:24,810
with Jessica and Lynn Hillenbrand from

371
00:16:28,880 --> 00:16:26,940
Caltech and this is still work in

372
00:16:31,430 --> 00:16:28,890
progress but I just wanted to show our

373
00:16:34,760 --> 00:16:31,440
what I think beautiful spectra is so

374
00:16:38,570 --> 00:16:34,770
here in black you see out of transit

375
00:16:41,120 --> 00:16:38,580
spectrum of was one of seven and then in

376
00:16:45,530 --> 00:16:41,130
red is the in transit spectrum which

377
00:16:49,580 --> 00:16:45,540
even by I just see this increase in

378
00:16:52,520 --> 00:16:49,590
absorption so when we look at just the

379
00:16:55,550 --> 00:16:52,530
average in transit spectrum this is what

380
00:16:57,320 --> 00:16:55,560
we get so we have slightly at lower

381
00:17:00,740 --> 00:16:57,330
version spectral resolution than the car

382
00:17:02,450 --> 00:17:00,750
Menace so we don't our line is not as

383
00:17:05,920 --> 00:17:02,460
deep because it's kind of smeared out

384
00:17:08,360 --> 00:17:05,930
but we get something like five percent

385
00:17:12,260 --> 00:17:08,370
trying to death at the line Center which

386
00:17:15,079 --> 00:17:12,270
if we assume is due to just an opaque

387
00:17:17,510 --> 00:17:15,089
like annulus it will correspond to

388
00:17:20,050 --> 00:17:17,520

equivalent radius of about to planetary

389
00:17:24,290 --> 00:17:20,060
radii so that's how far out we see

390
00:17:27,110 --> 00:17:24,300
helium at least and the transit depths

391
00:17:29,420 --> 00:17:27,120
are consistent with speak at all Hubble

392
00:17:32,420 --> 00:17:29,430
detection and allure to the owl Jimenez

393
00:17:34,970 --> 00:17:32,430
detection which were and this so they

394
00:17:37,310 --> 00:17:34,980
were taken within like a year and a half

395
00:17:40,250 --> 00:17:37,320
apart which corresponds to something

396
00:17:42,470 --> 00:17:40,260
like hundred orbital periods and the

397
00:17:45,020 --> 00:17:42,480
stealth of this signal is repeatable and

398
00:17:47,870 --> 00:17:45,030
stable for at least that many orbital

399
00:17:50,390 --> 00:17:47,880
periods and again we see a quite

400
00:17:53,049 --> 00:17:50,400
interesting line ratio of

401
00:17:56,840 --> 00:17:53,059
so the main component is four times

402
00:17:58,190 --> 00:17:56,850
stronger than the weak component and I

403
00:18:00,580 --> 00:17:58,200
will remind you in the optically thin

404
00:18:03,710 --> 00:18:00,590
median would expect it to be eight times

405
00:18:07,280 --> 00:18:03,720
deeper and so this tells us that it was

406
00:18:14,720 --> 00:18:07,290
107 we this corresponds to optical depth

407
00:18:15,919 --> 00:18:14,730
or about 2 so and then if we I think

408
00:18:17,720 --> 00:18:15,929
this is the probably the most

409
00:18:20,390 --> 00:18:17,730
interesting part of these observation is

410
00:18:23,539 --> 00:18:20,400
instead of just looking at the average

411
00:18:27,080 --> 00:18:23,549
in transit absorption spectrum if we try

412
00:18:30,250 --> 00:18:27,090
to break out spectra into time series

413
00:18:32,720 --> 00:18:30,260

and kind of group together all our

414
00:18:36,409 --> 00:18:32,730
spectra that were at the in the first

415
00:18:38,690 --> 00:18:36,419
maybe quarter of the transits then this

416
00:18:40,970 --> 00:18:38,700
shows the central partial part of the

417
00:18:42,770 --> 00:18:40,980
trends in central middle and this is the

418
00:18:46,610 --> 00:18:42,780
last part of the chance of including

419
00:18:50,810 --> 00:18:46,620
egress we see quite significant shifts

420
00:18:52,640 --> 00:18:50,820
in the line so the line starts first

421
00:18:55,100 --> 00:18:52,650
it's red shifted corresponding with

422
00:18:57,260 --> 00:18:55,110
respect to the rest frame wavelength

423
00:19:00,110 --> 00:18:57,270
then during the mid transits it's kind

424
00:19:02,690 --> 00:19:00,120
of right in the rest frame and then in

425
00:19:05,900 --> 00:19:02,700
in the later part of the transit the

426
00:19:09,530 --> 00:19:05,910
line is blue shifted and this has

427
00:19:13,539 --> 00:19:09,540
actually been seen before and or similar

428
00:19:19,280 --> 00:19:13,549
pressing the floor in was 69 and HD 189

429
00:19:20,539 --> 00:19:19,290
with almost similar shifts and this is

430
00:19:23,180 --> 00:19:20,549
telling us something really interesting

431
00:19:25,340 --> 00:19:23,190
about the dynamics of these upper layers

432
00:19:28,220 --> 00:19:25,350
of planetary atmospheres and it's also

433
00:19:31,190 --> 00:19:28,230
telling us that our simple model based

434
00:19:33,680 --> 00:19:31,200
on very symmetric part or winds are just

435
00:19:36,140 --> 00:19:33,690
not enough are not sufficient to explain

436
00:19:39,440 --> 00:19:36,150
these data so basically here I just

437
00:19:42,650 --> 00:19:39,450
demonstrate how if I take this my very

438
00:19:45,200 --> 00:19:42,660

symmetric part Irwin that just has a an

439
00:19:47,690 --> 00:19:45,210
outflow but it's all just the same in

440
00:19:50,000 --> 00:19:47,700
all directions and it kind of you can

441
00:19:51,890 --> 00:19:50,010
reproduce you can find a model that fits

442
00:19:53,930 --> 00:19:51,900
the mid trend so it's kind of fairly

443
00:19:56,690 --> 00:19:53,940
well but if you try to use the same

444
00:20:00,590 --> 00:19:56,700
model to reproduce the earlier phases

445
00:20:02,930 --> 00:20:00,600
the kind of ingress and egress you fail

446
00:20:03,870 --> 00:20:02,940
so it's basically telling us that we

447
00:20:05,789 --> 00:20:03,880
need to make our

448
00:20:08,760 --> 00:20:05,799
more complicated and add additional

449
00:20:10,560 --> 00:20:08,770
physics and learn the data is already

450
00:20:12,240 --> 00:20:10,570
rich enough to tell us more about the

451
00:20:14,640 --> 00:20:12,250
system than just what the simplest

452
00:20:19,169 --> 00:20:14,650
models are capable to tell us which is

453
00:20:22,830 --> 00:20:19,179
great so and we're trying to that's what

454
00:20:25,740 --> 00:20:22,840
we're going to try to do next so add

455
00:20:28,740 --> 00:20:25,750
more parameters to our models so maybe

456
00:20:32,909 --> 00:20:28,750
things like wind so when I talk about

457
00:20:34,740 --> 00:20:32,919
wind things so radial outflows I call

458
00:20:39,029 --> 00:20:34,750
outflows and anything that's horizontal

459
00:20:41,159 --> 00:20:39,039
I call wind and so maybe if we if we add

460
00:20:43,980 --> 00:20:41,169
that kind of horizontal motion we can

461
00:20:46,470 --> 00:20:43,990
reproduce these strong blue shifts or if

462
00:20:48,810 --> 00:20:46,480
we make atmospheric profiles different

463
00:20:51,299 --> 00:20:48,820

on the day side versus nighttime which

464
00:20:53,940 --> 00:20:51,309
is not unrealistic to expect I think we

465
00:20:55,470 --> 00:20:53,950
might have a better fit to the data but

466
00:20:57,470 --> 00:20:55,480
in order to start adding more and more

467
00:21:00,000 --> 00:20:57,480
parameters we first needed to make a

468
00:21:02,210 --> 00:21:00,010
radiative transfer code much faster and

469
00:21:04,890 --> 00:21:02,220
this was the work that was done by my

470
00:21:07,710 --> 00:21:04,900
REE student this summer Caleb Kurata

471
00:21:10,200 --> 00:21:07,720
he's an undergrad from Maryland and she

472
00:21:11,880 --> 00:21:10,210
did really an outstanding job at making

473
00:21:14,010 --> 00:21:11,890
the code faster and more efficient and

474
00:21:16,020 --> 00:21:14,020
so now we think we can really start

475
00:21:18,750 --> 00:21:16,030
adding more parameters and try to match

476
00:21:21,210 --> 00:21:18,760
the entire time series of spectra

477
00:21:23,039 --> 00:21:21,220
instead of just the average and transit

478
00:21:25,529 --> 00:21:23,049
spectrum and see what we can learn about

479
00:21:29,070 --> 00:21:25,539
the additional physical and dynamics of

480
00:21:31,890 --> 00:21:29,080
the atmosphere but even if that proves

481
00:21:33,659 --> 00:21:31,900
not to be enough we can always look for

482
00:21:36,590 --> 00:21:33,669
more complicated and complex structures

483
00:21:40,560 --> 00:21:36,600
so there has been a lot of work done on

484
00:21:42,330 --> 00:21:40,570
trying to model planetary winds and

485
00:21:44,789 --> 00:21:42,340
Celer winds and how they might interact

486
00:21:48,870 --> 00:21:44,799
some what kind of geometries they might

487
00:21:51,270 --> 00:21:48,880
form so in this work from 2015 and also

488
00:21:53,100 --> 00:21:51,280

John McCain's work from earlier this

489
00:21:55,770 --> 00:21:53,110
year and I'm sorry I forgot to mention

490
00:21:58,110 --> 00:21:55,780
that he has bolster above this so

491
00:22:01,230 --> 00:21:58,120
basically the material that escapes the

492
00:22:03,480 --> 00:22:01,240
planet might form a leading arm that

493
00:22:06,570 --> 00:22:03,490
kind of goes to the star and causes his

494
00:22:08,549 --> 00:22:06,580
redshift and then the trailing arm that

495
00:22:11,789 --> 00:22:08,559
is kind of blown away by stellar winds

496
00:22:13,860 --> 00:22:11,799
and you call these blue shift perhaps so

497
00:22:15,899 --> 00:22:13,870
this is work that I'm currently doing

498
00:22:17,520 --> 00:22:15,909
with Morgan MacLeod who's an Einstein

499
00:22:18,710 --> 00:22:17,530
fellow at the CF faith

500
00:22:21,330 --> 00:22:18,720
we're trying to create these 3d

501
00:22:23,790 --> 00:22:21,340
hydrodynamic simulations of planetary

502
00:22:26,160 --> 00:22:23,800
outflows for the moment we're just

503
00:22:27,420 --> 00:22:26,170
putting them in basically by hand and

504
00:22:30,750 --> 00:22:27,430
trying to see what happens to their

505
00:22:32,250 --> 00:22:30,760
geometry and dynamics and we're yet not

506
00:22:34,260 --> 00:22:32,260
trying to launch them really self

507
00:22:37,170 --> 00:22:34,270
consistently but that is something that

508
00:22:39,600 --> 00:22:37,180
we'll try to do in the future but yeah

509
00:22:42,870 --> 00:22:39,610
this is one way that we can try to get

510
00:22:45,240 --> 00:22:42,880
as these shifts by basically doing ray

511
00:22:48,840 --> 00:22:45,250
tracing through this material and see

512
00:22:52,950 --> 00:22:48,850
what kind of shifts we get so I kind of

513
00:22:55,680 --> 00:22:52,960

to wrap up this part so we can look for

514
00:22:57,930 --> 00:22:55,690
evidence of atmospheric escape if we

515
00:23:00,300 --> 00:22:57,940
observe this extended atmospheres of

516
00:23:02,490 --> 00:23:00,310
exoplanets so even though technically

517
00:23:04,710 --> 00:23:02,500
we're not probing the gas that's outside

518
00:23:06,840 --> 00:23:04,720
of the Roche radius so it's not like I'm

519
00:23:08,610 --> 00:23:06,850
and also where you actually see this

520
00:23:11,730 --> 00:23:08,620
tail of material that has already

521
00:23:14,370 --> 00:23:11,740
escaped in helium were probably probing

522
00:23:17,130 --> 00:23:14,380
these regions inside the Roche radius

523
00:23:19,650 --> 00:23:17,140
but if we can study dynamics of this

524
00:23:22,200 --> 00:23:19,660
material to sufficient detail and find

525
00:23:24,360 --> 00:23:22,210
evidence that there are these radial

526
00:23:26,070 --> 00:23:24,370
outflows then basically that tells us

527
00:23:29,010 --> 00:23:26,080
that this gas has to go somewhere so it

528
00:23:31,290 --> 00:23:29,020
has to escape at some point and I think

529
00:23:33,480 --> 00:23:31,300
the best way to move forward is to try

530
00:23:35,430 --> 00:23:33,490
to combine not just observations in the

531
00:23:38,070 --> 00:23:35,440
helium line but other lines that might

532
00:23:41,250 --> 00:23:38,080
be probing slightly different regions of

533
00:23:44,100 --> 00:23:41,260
the wind like H alpha or sodium doublet

534
00:23:46,050 --> 00:23:44,110
line and kind of use the information

535
00:23:48,570 --> 00:23:46,060
from all these lines to create a full

536
00:23:52,350 --> 00:23:48,580
picture of these planetary outflows and

537
00:23:54,750 --> 00:23:52,360
this is a some work that's been shown on

538
00:23:56,850 --> 00:23:54,760

Monday at posters by Julia and Ahriman

539
00:23:59,460 --> 00:23:56,860
and I hope you got a chance to see them

540
00:24:01,920 --> 00:23:59,470
they've been looking at sodium and H all

541
00:24:04,040 --> 00:24:01,930
fine they basically also see evidence of

542
00:24:06,330 --> 00:24:04,050
these outflows

543
00:24:09,750 --> 00:24:06,340
alright so people often ask me where

544
00:24:12,510 --> 00:24:09,760
should we look for these planets so here

545
00:24:15,270 --> 00:24:12,520
this plot shows basically the strength

546
00:24:17,820 --> 00:24:15,280
of the helium feature as a function of

547
00:24:20,040 --> 00:24:17,830
extreme UV flux from the host star and

548
00:24:22,980 --> 00:24:20,050
it's really interesting to see that all

549
00:24:25,650 --> 00:24:22,990
the detection is shown in blue are here

550
00:24:26,970 --> 00:24:25,660
and these are non detection and also

551
00:24:29,640 --> 00:24:26,980
some Atlanta attractions that are not on

552
00:24:31,230 --> 00:24:29,650
the plot so there seems there isn't

553
00:24:33,960 --> 00:24:31,240
things that

554
00:24:36,300 --> 00:24:33,970
whether or not we see helium and a

555
00:24:39,300 --> 00:24:36,310
planet might be related to how much XE

556
00:24:40,830 --> 00:24:39,310
reflux we see from the start but I think

557
00:24:43,110 --> 00:24:40,840
it's also really interesting to look at

558
00:24:46,340 --> 00:24:43,120
the spectral type types of these host

559
00:24:48,930 --> 00:24:46,350
stars for all of these planets that have

560
00:24:52,290 --> 00:24:48,940
strongest signals orbit around K type

561
00:24:57,210 --> 00:24:52,300
stars whereas these non detection czar

562
00:24:58,860 --> 00:24:57,220
around a M G and L as well so maybe this

563
00:25:03,750 --> 00:24:58,870

could be telling us something about how

564
00:25:05,880 --> 00:25:03,760
helium is excited and how how the

565
00:25:07,680 --> 00:25:05,890
strength of the signal depends on the

566
00:25:12,780 --> 00:25:07,690
properties of the host star

567
00:25:14,460 --> 00:25:12,790
so in this plot I basically show most of

568
00:25:16,260 --> 00:25:14,470
the processes that are involved in

569
00:25:18,750 --> 00:25:16,270
populating and depopulating the

570
00:25:20,400 --> 00:25:18,760
metastable helium level and for the sake

571
00:25:22,560 --> 00:25:20,410
of this talk you can ignore all of them

572
00:25:25,140 --> 00:25:22,570
except this thing in purple line which

573
00:25:27,740 --> 00:25:25,150
shows that the pink line is the main

574
00:25:29,730 --> 00:25:27,750
populating mechanism which is just

575
00:25:32,850 --> 00:25:29,740
fertilization of the ground state and

576
00:25:37,020 --> 00:25:32,860
then recombination and this is photons

577
00:25:38,790 --> 00:25:37,030
that live here and the popular you can

578
00:25:40,830 --> 00:25:38,800
be populate the helium triplet through

579
00:25:43,590 --> 00:25:40,840
direct for photo ionization from these

580
00:25:48,300 --> 00:25:43,600
photons which are here and basically I

581
00:25:49,860 --> 00:25:48,310
think the one of the main important key

582
00:25:52,680 --> 00:25:49,870
features to look in a stellar spectrum

583
00:25:55,080 --> 00:25:52,690
is the ratio of flux in this band and

584
00:25:58,290 --> 00:25:55,090
this band because this will tell us how

585
00:26:00,510 --> 00:25:58,300
the helium levels are populated and

586
00:26:04,580 --> 00:26:00,520
basically by analyzing that we see that

587
00:26:08,670 --> 00:26:04,590
K stars seem to be more most favorable

588
00:26:10,350 --> 00:26:08,680

more favorable than other types so

589
00:26:12,630 --> 00:26:10,360
basically just proving the same point if

590
00:26:15,120 --> 00:26:12,640
we increase the x-ray flux we increase

591
00:26:20,670 --> 00:26:15,130
the helium population level and if we

592
00:26:22,530 --> 00:26:20,680
decrease this mid UV flux we can again

593
00:26:25,560 --> 00:26:22,540
increase helium so basically what does

594
00:26:27,750 --> 00:26:25,570
this tell us it tells us that the

595
00:26:29,460 --> 00:26:27,760
whether or not we see helium signal will

596
00:26:32,250 --> 00:26:29,470
not only depend on the properties of the

597
00:26:33,630 --> 00:26:32,260
planetary atmosphere but also will

598
00:26:35,340 --> 00:26:33,640
depend on the properties of the host

599
00:26:37,560 --> 00:26:35,350
star so we need to take that into

600
00:26:41,190 --> 00:26:37,570
account when we make any interpretations

601
00:26:44,460 --> 00:26:41,200
of whether or not we've seen helium in

602
00:26:46,500 --> 00:26:44,470
some planets or not and also it's often

603
00:26:48,480 --> 00:26:46,510
miss I just want to point out that this

604
00:26:51,810 --> 00:26:48,490
doesn't mean that we absolutely cannot

605
00:26:53,940 --> 00:26:51,820
see helium around other stars and K

606
00:26:55,770 --> 00:26:53,950
stars we can if the conditions are right

607
00:26:58,980 --> 00:26:55,780
it's just that the conditions are most

608
00:27:00,690 --> 00:26:58,990
easily met around K stars and I'll just

609
00:27:02,880 --> 00:27:00,700
skip this slide it just shows that it's

610
00:27:05,330 --> 00:27:02,890
fairly important to have good models of

611
00:27:09,300 --> 00:27:05,340
XUV flux if we want to have reliable

612
00:27:10,680 --> 00:27:09,310
modeling and this is my summary I will

613
00:27:12,420 --> 00:27:10,690

just leave it up there because I'm out

614
00:27:29,550 --> 00:27:12,430
of time so thank you for your attention

615
00:27:31,860 --> 00:27:29,560
please state your name and affiliation

616
00:28:00,630 --> 00:27:31,870
even if people know you some people

617
00:28:05,490 --> 00:28:02,420
[Music]

618
00:28:08,600 --> 00:28:05,500
particular said you shot this the shift

619
00:28:10,980 --> 00:28:08,610
from from red to blue have you have you

620
00:28:12,930 --> 00:28:10,990
investigated how this would look like in

621
00:28:14,250 --> 00:28:12,940
the stellar frame just to make sure that

622
00:28:15,810 --> 00:28:14,260
it's not some kind of star signal that

623
00:28:18,090 --> 00:28:15,820
this you yeah yeah

624
00:28:21,390 --> 00:28:18,100
I haven't back up slides that I can

625
00:28:22,950 --> 00:28:21,400
maybe show you later because moves to an

626
00:28:25,320 --> 00:28:22,960
original presentation yeah it's fine

627
00:28:26,910 --> 00:28:25,330
yeah we did this is something with we're

628
00:28:28,740 --> 00:28:26,920
still checking but I think we did test

629
00:28:31,830 --> 00:28:28,750
and for example if you compare to that

630
00:28:34,800 --> 00:28:31,840
strong silicon line that's right to the

631
00:28:37,590 --> 00:28:34,810
blue in the search it just stays fixed

632
00:28:39,390 --> 00:28:37,600
and you can see by even by I in picks or

633
00:28:41,640 --> 00:28:39,400
when you plot pixels that the hilum line

634
00:28:57,430 --> 00:28:41,650
tab moves yeah I'd be happy to show you

635
00:29:11,919 --> 00:29:07,690
microphone yeah you know thanks Antonia

636
00:29:13,749 --> 00:29:11,929
and the result from GJ 1214 and was a

637
00:29:15,970 --> 00:29:13,759
non detection how much of that is

638
00:29:17,440 --> 00:29:15,980

affected by having clouds like do you

639
00:29:21,430 --> 00:29:17,450
expect that that feature to be strongly

640
00:29:23,710 --> 00:29:21,440
neutered as well yeah the GJ 1214 is

641
00:29:25,539 --> 00:29:23,720
actually very it was lower the wall

642
00:29:27,340 --> 00:29:25,549
spectral resolution so I think it's

643
00:29:32,850 --> 00:29:27,350
still not completely relaxed I would say

644
00:29:37,659 --> 00:29:32,860
but there has been some recent work

645
00:29:39,490 --> 00:29:37,669
doing simulations but I can't forget

646
00:29:41,499 --> 00:29:39,500
Venice forget the authors now but

647
00:29:43,749 --> 00:29:41,509
suggest that actually helium should

648
00:29:45,490 --> 00:29:43,759
extend out beyond that so it shouldn't

649
00:29:59,560 --> 00:29:45,500
mouth should not be an issue for the

650
00:30:01,419 --> 00:29:59,570
okay great talk Ted Temasek you Chicago

651
00:30:03,460 --> 00:30:01,429
so when you were showing the winds is

652
00:30:05,860 --> 00:30:03,470
kind of following up on Beorn's question

653
00:30:07,419 --> 00:30:05,870
were you removing the planetary rotation

654
00:30:09,580 --> 00:30:07,429
when you put it the wind speeds because

655
00:30:09,940 --> 00:30:09,590
they were quite fast sorry can you

656
00:30:11,409 --> 00:30:09,950
repeat

657
00:30:15,639 --> 00:30:11,419
were you removing the planetary rotation

658
00:30:17,769 --> 00:30:15,649
further I included in modeling so it's

659
00:30:19,330 --> 00:30:17,779
when I when I make my theoretical

660
00:30:32,139 --> 00:30:19,340
spectra includes like tidally locked

661
00:30:34,659 --> 00:30:32,149
rotations oh yeah included the question

662
00:30:36,190 --> 00:30:34,669
came up if you check if it's a stellar

663
00:30:37,629 --> 00:30:36,200

residual and you also looked into the

664
00:30:39,639 --> 00:30:37,639
rest of the McLoughlin effect because it

665
00:30:43,149 --> 00:30:39,649
would be bigger for a very extended

666
00:30:45,580 --> 00:30:43,159
atmosphere and but I thought about it

667
00:30:47,320 --> 00:30:45,590
but WASC 107 is very the star is a very

668
00:30:49,149 --> 00:30:47,330
slow door fader it's like I think

669
00:30:52,090 --> 00:30:49,159
Messiah is like two and a half

670
00:30:54,789 --> 00:30:52,100
kilometers per second and it's there's a

671
00:30:57,850 --> 00:30:54,799
paper by Diane Winne that suggests that

672
00:31:00,149 --> 00:30:57,860
it's it has very high obliquity so even

673
00:31:04,299 --> 00:31:00,159
on top of that small rotations probably

674
00:31:07,539 --> 00:31:04,309
transiting at high obliquity so I don't

675
00:31:09,730 --> 00:31:07,549
think we can explain 10 km/s shifts with

676
00:31:10,670 --> 00:31:09,740
with Ruster McLaughlin's but okay thank

677
00:31:14,750 --> 00:31:10,680
you