AbGradCon 2018

1
00:00:00,260 --> 00:00:12,070
[Music]

2
00:00:15,920 --> 00:00:14,360
at Yale University I'm working on some

3
00:00:17,510 --> 00:00:15,930
exoplanet atmospheric characterization

4
00:00:20,300 --> 00:00:17,520
and this talk I feel will be a little

5
00:00:21,890 --> 00:00:20,310
bit broad in scope because I'm mainly

6
00:00:25,610 --> 00:00:21,900
interested in looking at planet

7
00:00:28,370 --> 00:00:25,620
atmosphere as a very global scale and so

8
00:00:29,450 --> 00:00:28,380
the the first topic question I want to

9
00:00:30,800 --> 00:00:29,460
talk about is what do we know about

10
00:00:33,170 --> 00:00:30,810
exoplanet atmospheres from through

11
00:00:35,029 --> 00:00:33,180
cometary so the reason I point out

12
00:00:37,510 --> 00:00:35,039
photometry in general is that there are

13
00:00:40,910 --> 00:00:37,520

two main ways to observe an atmosphere

14
00:00:42,590 --> 00:00:40,920
we had a great introduction on you know

15
00:00:44,540 --> 00:00:42,600
transits and eclipses and phase curves

16
00:00:47,300 --> 00:00:44,550
and so those I'm gonna be brief here but

17
00:00:49,010 --> 00:00:47,310
so one way that you can you can try to

18
00:00:52,069 --> 00:00:49,020
learn something about an atmosphere is

19
00:00:57,049 --> 00:00:52,079
if you have a transit so this what's

20
00:00:58,460 --> 00:00:57,059
going on that's oh here we go okay so if

21
00:01:00,139 --> 00:00:58,470
you have if you're observing a planetary

22
00:01:01,670 --> 00:01:00,149
transit this red ring is supposed to be

23
00:01:04,459 --> 00:01:01,680
like the atmosphere it's a little

24
00:01:06,080 --> 00:01:04,469
exaggerated but it could not be and if

25
00:01:07,310 --> 00:01:06,090
you get absorption through that

26
00:01:09,170 --> 00:01:07,320
atmosphere that's a transmission

27
00:01:10,820 --> 00:01:09,180
spectrum you can learn possibly learn

28
00:01:13,580 --> 00:01:10,830
something about the composition of that

29
00:01:15,110 --> 00:01:13,590
atmosphere and then and then if you're

30
00:01:16,340 --> 00:01:15,120
if you're able to observe the planet

31
00:01:17,930 --> 00:01:16,350
through its whole orbit you can see

32
00:01:20,750 --> 00:01:17,940
different phases of the planet like the

33
00:01:22,850 --> 00:01:20,760
moon's phases and the clips will show

34
00:01:24,920 --> 00:01:22,860
you the full phase of the planet the

35
00:01:26,630 --> 00:01:24,930
dayside the side facing the star and

36
00:01:28,130 --> 00:01:26,640
that will give you mostly information

37
00:01:30,590 --> 00:01:28,140
about the thermal emission of the planet

38
00:01:32,450 --> 00:01:30,600

itself and but you don't get to see the

39
00:01:33,859 --> 00:01:32,460
Eclipse if the planet's orbit is edge-on

40
00:01:35,630 --> 00:01:33,869
and it's usually with the training

41
00:01:38,899 --> 00:01:35,640
protections so you see the decrement

42
00:01:40,340 --> 00:01:38,909
here you see the the the the portion of

43
00:01:42,649 --> 00:01:40,350
the planets emission that's not being

44
00:01:44,120 --> 00:01:42,659
seen relative to the Sun and so this is

45
00:01:45,679 --> 00:01:44,130
kind of an example of what a phase curve

46
00:01:47,179 --> 00:01:45,689
looks like a curve where you get you

47
00:01:48,080 --> 00:01:47,189
observe the planet in a photometric band

48
00:01:50,080 --> 00:01:48,090
through a whole orbit

49
00:01:52,609 --> 00:01:50,090
so here the transit pairs in eclipse

50
00:01:54,770 --> 00:01:52,619
okay so I'm gonna talk about phase

51
00:01:57,080 --> 00:01:54,780
photometry I really interesting phase

52
00:01:59,570 --> 00:01:57,090
curves here are three space telescopes

53
00:02:00,800 --> 00:01:59,580
that have done great work in looking at

54
00:02:01,249 --> 00:02:00,810
phase curves and then eclipses in

55
00:02:04,340 --> 00:02:01,259
general

56
00:02:07,130 --> 00:02:04,350
Kepler no this wasn't catalyst primary

57
00:02:09,410 --> 00:02:07,140
mission but you can you can use this two

58
00:02:12,350 --> 00:02:09,420
phase curves and that was invisible and

59
00:02:13,429 --> 00:02:12,360
then Hubble's Wide Field Camera 3 looked

60
00:02:14,500 --> 00:02:13,439
a little bit redder in the near infrared

61
00:02:16,030 --> 00:02:14,510
and but I

62
00:02:17,890 --> 00:02:16,040
going to talk about Spitzer bans which

63
00:02:20,979 --> 00:02:17,900

are in a little bit redder than that

64
00:02:22,210 --> 00:02:20,989
primarily because well these exoplanets

65
00:02:24,130 --> 00:02:22,220
their own thermal emissions a little bit

66
00:02:25,360 --> 00:02:24,140
cooler than their host stars so you're

67
00:02:28,690 --> 00:02:25,370
gonna move a little bit towards the

68
00:02:31,509 --> 00:02:28,700
redder including your infrared so let's

69
00:02:33,280 --> 00:02:31,519
talk first about eclipses why because

70
00:02:35,920 --> 00:02:33,290
well there's more of them it's easier to

71
00:02:39,220 --> 00:02:35,930
look for at a planet during just the

72
00:02:41,020 --> 00:02:39,230
Eclipse then for the whole orbit so I'll

73
00:02:44,410 --> 00:02:41,030
be very brief about this these are two

74
00:02:45,460 --> 00:02:44,420
plots from my recent paper I'd like to

75
00:02:47,440 --> 00:02:45,470
focus on the right one but to give

76
00:02:49,630 --> 00:02:47,450
context this is a this is a scatter plot

77
00:02:51,490 --> 00:02:49,640
of the Eclipse Tepes right that

78
00:02:53,680 --> 00:02:51,500
represents the dayside thermal emission

79
00:02:55,390 --> 00:02:53,690
of the planet relative to its thermal

80
00:02:57,550 --> 00:02:55,400
expectation so if the planet were

81
00:02:59,500 --> 00:02:57,560
radiating purely thermally at its

82
00:03:01,809 --> 00:02:59,510
equilibrium temperature that would be

83
00:03:04,059 --> 00:03:01,819
one here this dotted line and so

84
00:03:05,890 --> 00:03:04,069
anything above this is super thermal and

85
00:03:07,300 --> 00:03:05,900
so I'm gonna focus on the redder points

86
00:03:11,050 --> 00:03:07,310
here which just represent the Spitzer

87
00:03:12,970 --> 00:03:11,060
Iraq or infrared camera bands so zooming

88
00:03:14,770 --> 00:03:12,980

in and making a distribute showing a

89
00:03:16,720 --> 00:03:14,780
distribution of those fluxes relative to

90
00:03:18,520 --> 00:03:16,730
thermal we see we have some interesting

91
00:03:20,559 --> 00:03:18,530
distribution and so in the paper ice I

92
00:03:21,520 --> 00:03:20,569
sort of quantify that this approach is

93
00:03:23,680 --> 00:03:21,530
something called the log normal

94
00:03:26,080 --> 00:03:23,690
distribution if you remember from

95
00:03:28,210 --> 00:03:26,090
statistics if you have an observable or

96
00:03:31,210 --> 00:03:28,220
measurable quantity that is composed of

97
00:03:33,250 --> 00:03:31,220
many independent processes that are all

98
00:03:35,110 --> 00:03:33,260
combining to create this measurement

99
00:03:36,819 --> 00:03:35,120
then then in the limit of many

100
00:03:38,860 --> 00:03:36,829
independent processes you expect that

101
00:03:40,930 --> 00:03:38,870
some to approach a Gaussian distribution

102
00:03:42,939 --> 00:03:40,940
with some mean and standard deviation so

103
00:03:44,439 --> 00:03:42,949
in log space or correspondingly if you

104
00:03:46,509 --> 00:03:44,449
have that be a product of many

105
00:03:48,670 --> 00:03:46,519
independent processes you would expect

106
00:03:50,890 --> 00:03:48,680
to see a log normal distribution so why

107
00:03:53,559 --> 00:03:50,900
did I bring this up well it's suggesting

108
00:03:55,839 --> 00:03:53,569
that this distribution looking at all

109
00:03:57,670 --> 00:03:55,849
these eclipses as a whole is suggesting

110
00:03:59,949 --> 00:03:57,680
that there are many physical processes

111
00:04:01,539 --> 00:03:59,959
or maybe even instrumental processes

112
00:04:02,800 --> 00:04:01,549
that are creating this distribution so

113
00:04:05,050 --> 00:04:02,810

that seems like there's a lot going on

114
00:04:09,069 --> 00:04:05,060
here just looking at all the Eclipse

115
00:04:11,229 --> 00:04:09,079
steps as a whole and so if you have this

116
00:04:12,520 --> 00:04:11,239
observational data what can you what can

117
00:04:14,890 --> 00:04:12,530
you throw at it like what's a good

118
00:04:17,560 --> 00:04:14,900
physical physically motivated way to

119
00:04:19,539 --> 00:04:17,570
reproduce these observations well the

120
00:04:21,580 --> 00:04:19,549
most sophisticated way is to use a 3d

121
00:04:23,080 --> 00:04:21,590
climate model so these were originally

122
00:04:24,760 --> 00:04:23,090
developed for Earth climate models and

123
00:04:26,770 --> 00:04:24,770
I'm sure several of you that many of you

124
00:04:28,060 --> 00:04:26,780
have worked with these or seen these and

125
00:04:29,740 --> 00:04:28,070
so I'll be

126
00:04:32,140 --> 00:04:29,750
quickly just you know there are 3d

127
00:04:34,120 --> 00:04:32,150
treatment of the atmospheric physics and

128
00:04:35,500 --> 00:04:34,130
they also couple to the surface so if

129
00:04:37,600 --> 00:04:35,510
you have oceans or if you have carbon

130
00:04:39,910 --> 00:04:37,610
cycle all those sorts of things you can

131
00:04:41,140 --> 00:04:39,920
take care of that and most interesting

132
00:04:42,430 --> 00:04:41,150
to me is that you can capture the

133
00:04:44,230 --> 00:04:42,440
dynamics and the formation of things

134
00:04:46,540 --> 00:04:44,240
like clouds and the molecular absorption

135
00:04:47,950 --> 00:04:46,550
of species in the atmosphere so it's

136
00:04:50,860 --> 00:04:47,960
really useful and this is a really

137
00:04:52,470 --> 00:04:50,870
physically grounded approach and and

138
00:04:55,510 --> 00:04:52,480

very sophisticated to try to you know

139
00:04:56,860 --> 00:04:55,520
model now exoplanet atmosphere so a lot

140
00:05:00,670 --> 00:04:56,870
of work has been done to movies the

141
00:05:02,560 --> 00:05:00,680
exoplanets and so one of the things that

142
00:05:03,850 --> 00:05:02,570
gives us away from a takes us away from

143
00:05:04,990 --> 00:05:03,860
the earth like regime is particularly

144
00:05:07,720 --> 00:05:05,000
the orbital geometries of these

145
00:05:09,460 --> 00:05:07,730
exoplanets different stellar types how

146
00:05:10,450 --> 00:05:09,470
big and how you know in mass and radius

147
00:05:11,950 --> 00:05:10,460
of the planet that could change your

148
00:05:13,990 --> 00:05:11,960
surface gravity and also atmospheric

149
00:05:15,010 --> 00:05:14,000
composition and a lot of these planets

150
00:05:19,180 --> 00:05:15,020
that I'm going to talk about coming out

151
00:05:21,130 --> 00:05:19,190
data on our hot Jupiters so here I'm

152
00:05:24,250 --> 00:05:21,140
going to show some predictions from a

153
00:05:26,980 --> 00:05:24,260
very influential model from showman at

154
00:05:28,690 --> 00:05:26,990
all in 2009 so they used one of these

155
00:05:29,170 --> 00:05:28,700
three models to try to model a very

156
00:05:30,790 --> 00:05:29,180
well-studied

157
00:05:33,490 --> 00:05:30,800
hot Jupiter called to a nine four five

158
00:05:35,140 --> 00:05:33,500
eight and so here you're seeing the

159
00:05:37,120 --> 00:05:35,150
model curves and the Spitzer infrared

160
00:05:39,760 --> 00:05:37,130
bands and I'm just highlighting here in

161
00:05:41,050 --> 00:05:39,770
the red as the four point five model

162
00:05:44,410 --> 00:05:41,060
light curve and you see that at that

163
00:05:45,970 --> 00:05:44,420

time we weren't able to reproduce the

164
00:05:48,280 --> 00:05:45,980
Eclipse deaths so we have a

165
00:05:49,840 --> 00:05:48,290
sophisticated technique but we're

166
00:05:51,400 --> 00:05:49,850
missing something when we're trying to

167
00:05:54,070 --> 00:05:51,410
compare it to these data points right

168
00:05:56,650 --> 00:05:54,080
and so five years later paper buys

169
00:05:58,630 --> 00:05:56,660
element all take a full phase light

170
00:06:00,040 --> 00:05:58,640
curve in 4.5 so now you have data over

171
00:06:03,040 --> 00:06:00,050
the whole orbit in this four point five

172
00:06:04,870 --> 00:06:03,050
band and still and and here it's

173
00:06:07,390 --> 00:06:04,880
highlighting even more how what how the

174
00:06:10,540 --> 00:06:07,400
models disagree with the data and so

175
00:06:12,070 --> 00:06:10,550
we're this is pointing to that while you

176
00:06:13,930 --> 00:06:12,080
can have all the physics in there and

177
00:06:17,010 --> 00:06:13,940
it's all well-motivated

178
00:06:19,990 --> 00:06:17,020
at this point it's not clear that the

179
00:06:22,180 --> 00:06:20,000
that we can strain those physical

180
00:06:24,250 --> 00:06:22,190
properties using the data that we have

181
00:06:26,440 --> 00:06:24,260
available and so here you can see that

182
00:06:28,660 --> 00:06:26,450
the the minimum here is over predicted

183
00:06:30,550 --> 00:06:28,670
and so what we were thinking is well

184
00:06:31,930 --> 00:06:30,560
we'd want to at least fit the broad

185
00:06:34,300 --> 00:06:31,940
properties of these light curves right

186
00:06:36,100 --> 00:06:34,310
so you want to fit say the amplitude of

187
00:06:37,480 --> 00:06:36,110
the light curve you want to fit you know

188
00:06:39,940 --> 00:06:37,490

so that would be also the Eclipse step

189
00:06:41,010 --> 00:06:39,950
so you'd also want to fit where this

190
00:06:43,170 --> 00:06:41,020
minimum occurs

191
00:06:44,670 --> 00:06:43,180
if you remember during transit you've

192
00:06:46,439 --> 00:06:44,680
got the new phase of the planet the

193
00:06:47,939 --> 00:06:46,449
Nightside and so you expect maybe that

194
00:06:49,710 --> 00:06:47,949
the minimum temperature or the minimum

195
00:06:52,020 --> 00:06:49,720
flux would be during the nights the the

196
00:06:53,309 --> 00:06:52,030
new phase which is during transit but if

197
00:06:54,450 --> 00:06:53,319
you see the minimum that's offset a

198
00:06:55,770 --> 00:06:54,460
little bit that could tell you something

199
00:06:56,790 --> 00:06:55,780
about the circulation the atmosphere

200
00:06:58,740 --> 00:06:56,800
because that's telling you something as

201
00:07:01,260 --> 00:06:58,750
you know like a wind is moving the the

202
00:07:03,360 --> 00:07:01,270
cold spot away from that expectation so

203
00:07:05,369 --> 00:07:03,370
that's one metric that you can fit so

204
00:07:06,689 --> 00:07:05,379
these are all empirical properties of

205
00:07:08,850 --> 00:07:06,699
the light curve that you would like to

206
00:07:12,089 --> 00:07:08,860
fit to first order before you start

207
00:07:13,589 --> 00:07:12,099
moving on and and it's difficult it's

208
00:07:15,839 --> 00:07:13,599
compounded by the fact that this is an

209
00:07:18,240 --> 00:07:15,849
example of what the spits are like our

210
00:07:20,879 --> 00:07:18,250
spits of photometry starts out as so

211
00:07:23,219 --> 00:07:20,889
this is the raw photometry and so as

212
00:07:26,399 --> 00:07:23,229
young a tall paper from 2017 they

213
00:07:28,260 --> 00:07:26,409

outline a really good outline of how how

214
00:07:29,850 --> 00:07:28,270
much work has gone into reduce spits or

215
00:07:31,770 --> 00:07:29,860
light curve data to get something that

216
00:07:34,320 --> 00:07:31,780
you can use right and even though

217
00:07:36,240 --> 00:07:34,330
there's been a lot of work to to reduce

218
00:07:39,689 --> 00:07:36,250
the data and try to get at the real

219
00:07:41,100 --> 00:07:39,699
physical signal there is in many of

220
00:07:42,270 --> 00:07:41,110
these works a lot of these experts are

221
00:07:44,730 --> 00:07:42,280
pointing out that there could still be

222
00:07:46,860 --> 00:07:44,740
very very well be uncharacterized noise

223
00:07:48,600 --> 00:07:46,870
sources and in the in the data and so

224
00:07:51,089 --> 00:07:48,610
that's also hindering us that could be

225
00:07:52,320 --> 00:07:51,099
one of or several of the physical

226
00:07:55,290 --> 00:07:52,330
processes that are giving us that

227
00:08:00,689 --> 00:07:55,300
distribution of eclipsed depths so our

228
00:08:04,680 --> 00:08:00,699
approach so our approach is to start

229
00:08:07,200 --> 00:08:04,690
very simply so we we use the most simple

230
00:08:08,969 --> 00:08:07,210
physical model and so as a grad student

231
00:08:11,430 --> 00:08:08,979
this is nice for me because I can code

232
00:08:14,309 --> 00:08:11,440
up a model that takes four parameters so

233
00:08:15,809 --> 00:08:14,319
we take a planet that rotates we have a

234
00:08:18,089 --> 00:08:15,819
planet that heats up and cools down with

235
00:08:19,740 --> 00:08:18,099
some characteristic time scale we have a

236
00:08:21,240 --> 00:08:19,750
planet that stays some minimum

237
00:08:23,550 --> 00:08:21,250
temperature and that can encompass

238
00:08:25,920 --> 00:08:23,560

anything that's not the stellar heating

239
00:08:27,570 --> 00:08:25,930
and we have an albedo so the planet has

240
00:08:30,779 --> 00:08:27,580
some reflectivity again this is very

241
00:08:32,130 --> 00:08:30,789
very basic and we also again know the

242
00:08:33,690 --> 00:08:32,140
orbital geometry of some of these

243
00:08:35,639 --> 00:08:33,700
systems that we like to model the

244
00:08:37,350 --> 00:08:35,649
stellar and the mass and the radius and

245
00:08:40,500 --> 00:08:37,360
the temperature of the star and then the

246
00:08:41,790 --> 00:08:40,510
internal band passes like Spitzer and so

247
00:08:43,409 --> 00:08:41,800
we can model a generated temperature map

248
00:08:44,670 --> 00:08:43,419
we can involve that with how you're

249
00:08:46,500 --> 00:08:44,680
viewing it to get through light curves

250
00:08:48,660 --> 00:08:46,510
and then you can you can try to optimize

251
00:08:52,530 --> 00:08:48,670
to find the best fit parameter is a be

252
00:08:53,760 --> 00:08:52,540
score and so here's a non animated

253
00:08:54,810 --> 00:08:53,770
version of what the kind of the data

254
00:08:56,130 --> 00:08:54,820
price we get out so this is

255
00:08:59,250 --> 00:08:56,140
designing the orbit of another well have

256
00:09:00,570 --> 00:08:59,260
studied hot Jupiter 189 733 and here

257
00:09:02,340 --> 00:09:00,580
just kind of showing you where we have

258
00:09:03,780 --> 00:09:02,350
orbit data here's the data and these

259
00:09:05,790 --> 00:09:03,790
black dots and here's how we're fitting

260
00:09:09,150 --> 00:09:05,800
the data so we can do multiple fits and

261
00:09:10,830 --> 00:09:09,160
different wavelengths and we do this for

262
00:09:12,120 --> 00:09:10,840
a lot of planets in fact there are 13

263
00:09:13,410 --> 00:09:12,130

planets that we looked at some of them

264
00:09:14,700 --> 00:09:13,420
are eccentric and I'll get to why we

265
00:09:17,130 --> 00:09:14,710
like eccentric plants or I like these

266
00:09:18,780 --> 00:09:17,140
centered planets and when we compare

267
00:09:20,790 --> 00:09:18,790
these models at least at the first-order

268
00:09:23,190 --> 00:09:20,800
level we're doing a pretty good job and

269
00:09:25,470 --> 00:09:23,200
so what this is suggesting is that there

270
00:09:26,940 --> 00:09:25,480
is a need at this point that even though

271
00:09:28,980 --> 00:09:26,950
Spitzer has done an amazing amount of

272
00:09:30,780 --> 00:09:28,990
work it wasn't designed to do exoplanet

273
00:09:33,030 --> 00:09:30,790
asks for a characterization so we need

274
00:09:34,170 --> 00:09:33,040
to be aware of how how we approach the

275
00:09:36,930 --> 00:09:34,180
data especially when we're moving

276
00:09:38,610 --> 00:09:36,940
forward to James Webb one thing I wanted

277
00:09:39,960 --> 00:09:38,620
to point out is that circular orbits and

278
00:09:42,150 --> 00:09:39,970
this is motivating I like eccentric

279
00:09:43,620 --> 00:09:42,160
orbits they can have this even with the

280
00:09:45,720 --> 00:09:43,630
for printer model you expect there's

281
00:09:47,340 --> 00:09:45,730
some difficulties and one thing is that

282
00:09:50,010 --> 00:09:47,350
we have a time scale degeneracy so I

283
00:09:51,480 --> 00:09:50,020
pointed out this phase offset and so

284
00:09:53,790 --> 00:09:51,490
this phase offset you can quantify how

285
00:09:56,550 --> 00:09:53,800
displace that is and that gives that's

286
00:09:59,490 --> 00:09:56,560
represented in our model by a a rotation

287
00:10:01,290 --> 00:09:59,500
period that captures any deviation from

288
00:10:02,850 --> 00:10:01,300

synchronicity or tidal walking where the

289
00:10:04,770 --> 00:10:02,860
planet it has one day sight in one night

290
00:10:07,050 --> 00:10:04,780
side so if you wiggle that away from

291
00:10:09,210 --> 00:10:07,060
that that limit then you can get

292
00:10:10,890 --> 00:10:09,220
effectively wins or capture that wins

293
00:10:12,120 --> 00:10:10,900
and so this is kind of just a heat map

294
00:10:14,130 --> 00:10:12,130
with the likelihoods and you can see

295
00:10:16,260 --> 00:10:14,140
that there's a large energy between how

296
00:10:18,870 --> 00:10:16,270
much you wiggle that rotation period and

297
00:10:19,950 --> 00:10:18,880
what your your heating time scale is so

298
00:10:22,260 --> 00:10:19,960
those can kind of play off each other

299
00:10:23,520 --> 00:10:22,270
and that's that's partially due to the

300
00:10:25,560 --> 00:10:23,530
cement symmetry of the orbit you're

301
00:10:27,720 --> 00:10:25,570
always getting the same installation or

302
00:10:29,610 --> 00:10:27,730
a stellar heating but eccentric planets

303
00:10:31,980 --> 00:10:29,620
could break the degeneracy so here I'm

304
00:10:34,340 --> 00:10:31,990
showing a hat p2b which is an eccentric

305
00:10:36,540 --> 00:10:34,350
planet at eccentricity 0.5 interested

306
00:10:38,670 --> 00:10:36,550
and these are really really interesting

307
00:10:40,410 --> 00:10:38,680
because of the time variable heating

308
00:10:42,960 --> 00:10:40,420
from its host star so you can see here

309
00:10:46,440 --> 00:10:42,970
at it's almost I think it's like a

310
00:10:48,120 --> 00:10:46,450
factor of 3 to 5 difference this I'll

311
00:10:49,290 --> 00:10:48,130
just kind of put this as a video I had a

312
00:10:49,740 --> 00:10:49,300
video too showing like it's kind of

313
00:10:51,120 --> 00:10:49,750

thing it

314
00:10:53,790 --> 00:10:51,130
we're goals around you can you can look

315
00:10:57,540 --> 00:10:53,800
it up oh if you want I can save you a

316
00:10:58,890 --> 00:10:57,550
link but in summary so this is the first

317
00:11:00,450 --> 00:10:58,900
part of my talk is that saying that you

318
00:11:01,620 --> 00:11:00,460
know photometry can capture these

319
00:11:03,270 --> 00:11:01,630
properties and tell us a lot about the

320
00:11:05,040 --> 00:11:03,280
atmosphere but we really need to be

321
00:11:07,410 --> 00:11:05,050
careful about how we characterize our

322
00:11:08,010 --> 00:11:07,420
intrumental response and so for the next

323
00:11:09,360 --> 00:11:08,020
couple

324
00:11:11,010 --> 00:11:09,370
I want to talk about another project

325
00:11:12,780 --> 00:11:11,020
that's a little more theoretical and I

326
00:11:14,910 --> 00:11:12,790
thought it'd be a little more related to

327
00:11:15,840 --> 00:11:14,920
a lot of the astrobiology at their side

328
00:11:18,300 --> 00:11:15,850
what's going on here

329
00:11:20,579 --> 00:11:18,310
if we take this photometric approach

330
00:11:22,829 --> 00:11:20,589
could we could we learn something about

331
00:11:23,970 --> 00:11:22,839
rotation on eccentric ocean planets so

332
00:11:26,880 --> 00:11:23,980
I'm going to start with a very basic

333
00:11:30,889 --> 00:11:26,890
ocean planet model an earth-like planet

334
00:11:34,889 --> 00:11:30,899
on an orbit that is eccentric

335
00:11:38,790 --> 00:11:34,899
that's eccentric but you can you can fix

336
00:11:40,650 --> 00:11:38,800
the total orbit average stellar heating

337
00:11:42,510 --> 00:11:40,660
to match that of Earth and that's what's

338
00:11:44,160 --> 00:11:42,520

characterized by this mean flux

339
00:11:45,960 --> 00:11:44,170
approximation so all this is saying is

340
00:11:48,210 --> 00:11:45,970
that when you change the eccentricity

341
00:11:51,360 --> 00:11:48,220
here's how you scale the orbit such that

342
00:11:53,040 --> 00:11:51,370
you preserve this value of F over F flux

343
00:11:55,079 --> 00:11:53,050
over the earth blocks so just fix that

344
00:11:56,340 --> 00:11:55,089
to one tells you how to scale your orbit

345
00:11:58,350 --> 00:11:56,350
so now we know how our orbit should be

346
00:12:00,930 --> 00:11:58,360
structured to preserve that amount of

347
00:12:03,570 --> 00:12:00,940
heating and then we consider two

348
00:12:05,250 --> 00:12:03,580
rotation regimes so one will be an

349
00:12:07,320 --> 00:12:05,260
earthlike rotation and one would be

350
00:12:09,449 --> 00:12:07,330
something that extends the idea of tidal

351
00:12:11,070 --> 00:12:09,459
locking to an eccentric case using the

352
00:12:13,319 --> 00:12:11,080
same tidal arguments tidal heating

353
00:12:14,760 --> 00:12:13,329
arguments for eccentric planets there's

354
00:12:16,440 --> 00:12:14,770
a pseudo synchronous rate that remains

355
00:12:18,269 --> 00:12:16,450
pretty slow of order the orbital period

356
00:12:20,970 --> 00:12:18,279
until very high eccentricities so we're

357
00:12:23,519 --> 00:12:20,980
gonna call this the slow case and so we

358
00:12:26,519 --> 00:12:23,529
can model these planets we can we can

359
00:12:28,440 --> 00:12:26,529
look at the distribution of the ice and

360
00:12:30,210 --> 00:12:28,450
the ice cover and the open ocean cover

361
00:12:31,500 --> 00:12:30,220
and see what the surface temperatures

362
00:12:33,090 --> 00:12:31,510
are and so I'm just kind of showing you

363
00:12:36,120 --> 00:12:33,100

that you know you've probably seen some

364
00:12:37,560 --> 00:12:36,130
of these characteristic patterns of the

365
00:12:39,870 --> 00:12:37,570
eyeball where you see like a very

366
00:12:43,650 --> 00:12:39,880
concentrated melting point and then a

367
00:12:45,480 --> 00:12:43,660
more longitudinally symmetric point and

368
00:12:47,329 --> 00:12:45,490
so all us you know I'm also just crying

369
00:12:49,650 --> 00:12:47,339
pointing out to say that we did this and

370
00:12:51,000 --> 00:12:49,660
pressure and temperature some things you

371
00:12:52,530 --> 00:12:51,010
can also imagine in the atmosphere and

372
00:12:55,290 --> 00:12:52,540
so what you might expect is that for the

373
00:12:57,269 --> 00:12:55,300
slow rotating planets right around the

374
00:12:59,010 --> 00:12:57,279
point of closest approach periastron

375
00:13:01,470 --> 00:12:59,020
where there's the most heating remember

376
00:13:03,690 --> 00:13:01,480
these are eccentric planets that you

377
00:13:05,519 --> 00:13:03,700
would expect because the the planets are

378
00:13:07,769 --> 00:13:05,529
more slowly rotating they'll they'll

379
00:13:09,300 --> 00:13:07,779
have more time to evaporate and give a

380
00:13:11,370 --> 00:13:09,310
greater column density of water in the

381
00:13:13,110 --> 00:13:11,380
atmosphere so in a very very basic

382
00:13:15,000 --> 00:13:13,120
approach but we want to see whether this

383
00:13:16,949 --> 00:13:15,010
this could give a signature that could

384
00:13:19,680 --> 00:13:16,959
tell you in photometry whether you have

385
00:13:21,500 --> 00:13:19,690
a slow rotator or a fast rotator and so

386
00:13:24,800 --> 00:13:21,510
what we did was we took James Webb they

387
00:13:26,990 --> 00:13:24,810
and we simulated some light curves so

388
00:13:29,330 --> 00:13:27,000

these are all in the mid-infrared from

389
00:13:30,560 --> 00:13:29,340
5.6 micron to 25 and a half micron and

390
00:13:32,000 --> 00:13:30,570
so you're just seeing kind of the

391
00:13:34,040 --> 00:13:32,010
differences here so one of these and the

392
00:13:36,020 --> 00:13:34,050
diamond endpoints is the slow rotator

393
00:13:37,400 --> 00:13:36,030
and the plus signs are for Earth and so

394
00:13:38,690 --> 00:13:37,410
I'm just pointing out here that in these

395
00:13:39,800 --> 00:13:38,700
bands you can see that there's a

396
00:13:41,510 --> 00:13:39,810
characteristic difference and

397
00:13:44,780 --> 00:13:41,520
interestingly there might be something

398
00:13:45,860 --> 00:13:44,790
you know so even in the broadband you

399
00:13:47,750 --> 00:13:45,870
know there's a there's a absorption

400
00:13:51,320 --> 00:13:47,760
feature of water in this second band

401
00:13:52,700 --> 00:13:51,330
here at 770 or 7.7 microns so I was

402
00:13:54,520 --> 00:13:52,710
thinking what if we took a color so we

403
00:13:57,110 --> 00:13:54,530
took the ratio of two light curves and

404
00:13:58,520 --> 00:13:57,120
so what I'm trying to point out here is

405
00:13:59,720 --> 00:13:58,530
that if you take if you're able to

406
00:14:02,090 --> 00:13:59,730
observe in two bands and get kind of a

407
00:14:03,050 --> 00:14:02,100
color a light curve color band then you

408
00:14:04,940 --> 00:14:03,060
could see a pretty interesting

409
00:14:06,230 --> 00:14:04,950
difference potentially depending on

410
00:14:07,250 --> 00:14:06,240
where you observe even if you're not

411
00:14:09,500 --> 00:14:07,260
even able to observe the whole light

412
00:14:11,360 --> 00:14:09,510
curve if you're this is one particular

413
00:14:13,400 --> 00:14:11,370

tube viewing geometry but if you looked

414
00:14:14,810 --> 00:14:13,410
right at eclipsed you may be able to see

415
00:14:17,450 --> 00:14:14,820
a pretty big difference in that color

416
00:14:18,950 --> 00:14:17,460
metric may be able to tell you whether

417
00:14:21,320 --> 00:14:18,960
you're looking at a slow rotating planet

418
00:14:32,360 --> 00:14:21,330
or a fast rotating planet with that I

419
00:14:40,190 --> 00:14:32,370
think I will take questions thank you do

420
00:14:49,940 --> 00:14:40,200
you have any questions Arthur when you

421
00:15:13,250 --> 00:14:49,950
showed AC 209 right so you said you

422
00:15:15,950 --> 00:15:13,260
couldn't fit into the data right so

423
00:15:17,480 --> 00:15:15,960
that's what I'm so yes so the idea is

424
00:15:19,100 --> 00:15:17,490
that even with even with a full phase

425
00:15:21,110 --> 00:15:19,110
curve right we're not be able finsihed

426
00:15:22,850 --> 00:15:21,120
and and again if you if in this paper

427
00:15:24,740 --> 00:15:22,860
I'm selling and the author's point out

428
00:15:26,780 --> 00:15:24,750
that there that they think that it's due

429
00:15:28,070 --> 00:15:26,790
to eight as you point out a disagreement

430
00:15:29,600 --> 00:15:28,080
in the carbon chemistry that there may

431
00:15:31,400 --> 00:15:29,610
be some disequilibrium chemistry and the

432
00:15:33,960 --> 00:15:31,410
methane on the day and night side that

433
00:15:44,040 --> 00:15:33,970
you're not capturing work we're not

434
00:15:45,389 --> 00:15:44,050
and accurately with the model sorry yeah

435
00:15:48,720 --> 00:15:45,399
this might have been some weird data

436
00:15:51,030 --> 00:15:48,730
them from not tonight but have you

437
00:15:53,249 --> 00:15:51,040
looked at any other hot Jupiters which

438
00:15:58,850 --> 00:15:53,259

actually have has like a thermal

439
00:16:01,290 --> 00:15:58,860
inversion inhibition feature right so so

440
00:16:03,600 --> 00:16:01,300
so we have looked at planets that where

441
00:16:05,610 --> 00:16:03,610
they have been modeled using inversion I

442
00:16:08,009 --> 00:16:05,620
would say that our model itself does not

443
00:16:09,509 --> 00:16:08,019
at all capture it does not apply a

444
00:16:14,160 --> 00:16:09,519
thermal inversion model to try to

445
00:16:16,439 --> 00:16:14,170
capture the photometry even I would say

446
00:16:18,059 --> 00:16:16,449
that it even with inversions in the

447
00:16:19,889 --> 00:16:18,069
atmosphere there still remains a

448
00:16:22,769 --> 00:16:19,899
difficulty in capturing that inversion

449
00:16:25,069 --> 00:16:22,779
there's still a difficulty to capture

450
00:16:29,160 --> 00:16:25,079
the whole shape of the light curves even

451
00:16:31,499 --> 00:16:29,170
recently so it may not it may not it may

452
00:16:32,970 --> 00:16:31,509
be very well I it seems very clear that

453
00:16:34,800 --> 00:16:32,980
there are inversion layers and planets

454
00:16:35,970 --> 00:16:34,810
but whether you can take that and

455
00:16:37,619 --> 00:16:35,980
constrain the properties of that

456
00:16:39,119 --> 00:16:37,629
inversion within the context of the

457
00:16:40,619 --> 00:16:39,129
whole atmosphere in order to get the

458
00:16:47,460 --> 00:16:40,629
full picture with the light curve is

459
00:16:53,140 --> 00:16:47,470
another question so any other questions