
HOT JUPITERS: DYNAMICS, CHEMISTRY & CLOUDS
EMILY RAUSCHER

1
00:00:10,209 --> 00:00:04,150
[Music]

2
00:00:13,270 --> 00:00:10,219
I will also start by saying I love this

3
00:00:16,060 --> 00:00:13,280
conference wonderful series for the new

4
00:00:19,330 --> 00:00:16,070
who are new twists welcome I hope you

5
00:00:21,819 --> 00:00:19,340
learn a lot in recognition but people

6
00:00:23,950 --> 00:00:21,829
come here to learn a lot in case there

7
00:00:26,229 --> 00:00:23,960
are you hidden people if the audience

8
00:00:29,830 --> 00:00:26,239
who don't know what a hot Jupiter is I

9
00:00:32,800 --> 00:00:29,840
put in to scale right here where you

10
00:00:35,920 --> 00:00:32,810
have a gas giant several stellar radii

11
00:00:38,470 --> 00:00:35,930
away from its most star we expect them

12
00:00:41,140 --> 00:00:38,480
to be tidally synchronized so very hot

13
00:00:46,000 --> 00:00:41,150

constant deicide and a cold night side

14
00:00:50,320 --> 00:00:46,010
and weirdness this is the title that I

15
00:00:55,900 --> 00:00:50,330
was given but being an awkward I thought

16
00:01:00,340 --> 00:00:55,910
it needed an Oxford comma both because

17
00:01:03,340 --> 00:01:00,350
that's how I roll but also because in my

18
00:01:06,010 --> 00:01:03,350
mind it makes more sense I'll get to

19
00:01:09,999 --> 00:01:06,020
that in a little bit I'll get to that

20
00:01:13,510 --> 00:01:10,009
because if I'm saying that it's dynamic

21
00:01:15,730 --> 00:01:13,520
comma chemistry and clouds I'm in a

22
00:01:18,910 --> 00:01:15,740
mindset that I have some dynamics going

23
00:01:21,340 --> 00:01:18,920
on and then within that context there's

24
00:01:23,770 --> 00:01:21,350
some chemistry and clouds going on but

25
00:01:26,529 --> 00:01:23,780
really I think it's more appropriate to

26
00:01:30,730 --> 00:01:26,539
have the Oxford comma because these

27
00:01:33,429 --> 00:01:30,740
three aspects of hemispheres are all

28
00:01:37,149 --> 00:01:33,439
interrelated and they influence both

29
00:01:39,160 --> 00:01:37,159
ways back and forth right so this is the

30
00:01:41,289 --> 00:01:39,170
context that we need to think about when

31
00:01:44,949 --> 00:01:41,299
we're thinking about what's going on in

32
00:01:48,279 --> 00:01:44,959
hot Jupiter atmospheres also I have a

33
00:01:49,359 --> 00:01:48,289
strong three dimensional bias so I must

34
00:01:50,800 --> 00:01:49,369
be on point out there all three

35
00:01:53,819 --> 00:01:50,810
dimensional things we have to worry

36
00:02:00,819 --> 00:01:57,599
so we'll dig into some of these

37
00:02:03,399 --> 00:02:00,829
interdependencies before I get started

38
00:02:07,839 --> 00:02:03,409

there's a lot of really exciting stuff

39
00:02:09,910 --> 00:02:07,849
going on in this set of topics this is

40
00:02:13,060 --> 00:02:09,920
not a comprehensive literature reviews

41
00:02:15,220 --> 00:02:13,070
so apology is I've tried to smash alot

42
00:02:16,600 --> 00:02:15,230
of material in here I've probably

43
00:02:19,750 --> 00:02:16,610
forgotten your wonderful

44
00:02:22,000 --> 00:02:19,760
paper I'm sorry please feel free sort of

45
00:02:24,790 --> 00:02:22,010
raise it as a comments and the questions

46
00:02:25,900 --> 00:02:24,800
afterwards especially if you want to

47
00:02:28,390 --> 00:02:25,910
highlight works by more junior people

48
00:02:30,820 --> 00:02:28,400
that's awesome

49
00:02:33,310 --> 00:02:30,830
and thinking about junior people I also

50
00:02:36,370 --> 00:02:33,320
want to say come work on these topics

51
00:02:38,650 --> 00:02:36,380
there's so much we don't know right even

52
00:02:41,500 --> 00:02:38,660
as Adam was saying for solar system

53
00:02:43,330 --> 00:02:41,510
modeling there hasn't been necessarily

54
00:02:45,580 --> 00:02:43,340
as much as you would have thought and

55
00:02:48,340 --> 00:02:45,590
hot Jupiters frequently figuring stuff

56
00:02:50,080 --> 00:02:48,350
out so at least in theory space there's

57
00:02:52,449 --> 00:02:50,090
plenty of interesting problems to work

58
00:02:55,720 --> 00:02:52,459
on come work on all of them I remember

59
00:02:57,250 --> 00:02:55,730
when I was junior looking at the leaders

60
00:02:58,960 --> 00:02:57,260
of the field and thinking how could I

61
00:03:00,520 --> 00:02:58,970
ever possibly find a space when there's

62
00:03:03,880 --> 00:03:00,530
already all these people working on it

63
00:03:10,060 --> 00:03:03,890

it's spams there's tons to work on so

64
00:03:12,790 --> 00:03:10,070
come play with that okay so in my

65
00:03:14,979 --> 00:03:12,800
abstract I decided to be a little bit

66
00:03:17,530 --> 00:03:14,989
cheeky maybe and I said we don't really

67
00:03:20,500 --> 00:03:17,540
understand that the basic picture of hot

68
00:03:24,180 --> 00:03:20,510
Jupiters maybe we do maybe we don't

69
00:03:27,130 --> 00:03:24,190
first I'm going to kind of explain this

70
00:03:28,720 --> 00:03:27,140
standard picture that has developed so

71
00:03:30,850 --> 00:03:28,730
this is the framework that many of us

72
00:03:33,820 --> 00:03:30,860
think of when we think of how hot

73
00:03:36,759 --> 00:03:33,830
Jupiter atmospheres operate and I'll

74
00:03:44,229 --> 00:03:36,769
start by going back to some history and

75
00:03:47,350 --> 00:03:44,239
the original GCM OGC thank you next

76
00:03:51,130 --> 00:03:47,360
before we put hot Jupiters in the titles

77
00:03:54,430 --> 00:03:51,140
of papers and so this is I think the

78
00:03:57,100 --> 00:03:54,440
first GCM of a hot Jupiter and I notice

79
00:03:59,830 --> 00:03:57,110
when I look back at that in the abstract

80
00:04:02,259 --> 00:03:59,840
Tristan madam were very smart to point

81
00:04:05,050 --> 00:04:02,269
out okay first of all huge day/night

82
00:04:07,390 --> 00:04:05,060
differences very strong wind speeds and

83
00:04:09,370 --> 00:04:07,400
then I noticed substantial departures

84
00:04:11,800 --> 00:04:09,380
from chemical equilibrium are expected

85
00:04:14,979 --> 00:04:11,810
the cloud coverage to Penn center took

86
00:04:17,229 --> 00:04:14,989
me on the dynamics right cool already

87
00:04:20,380 --> 00:04:17,239
all been done chemistry dynamics and

88
00:04:21,969 --> 00:04:20,390

clouds right from the beginning there's

89
00:04:24,310 --> 00:04:21,979
been some work taker things out in the

90
00:04:26,710 --> 00:04:24,320
meantime but here's the basic result

91
00:04:29,740 --> 00:04:26,720
right and this hasn't changed very much

92
00:04:30,190 --> 00:04:29,750
here's something like temperature as a

93
00:04:31,960 --> 00:04:30,200
function

94
00:04:34,480 --> 00:04:31,970
latitude and launched it on the planet

95
00:04:36,460 --> 00:04:34,490
and the winds are showing or the arrows

96
00:04:39,190 --> 00:04:36,470
are showing you winds and so there's

97
00:04:41,590 --> 00:04:39,200
this classic standard picture where we

98
00:04:44,770 --> 00:04:41,600
developed the eastward jet along the

99
00:04:46,750 --> 00:04:44,780
equator and it takes the gas that's at

100
00:04:49,570 --> 00:04:46,760
the central point the subsolar point

101
00:04:51,460 --> 00:04:49,580
facing the star and it infects it

102
00:04:54,250 --> 00:04:51,470
downstream a little bit before it has a

103
00:04:57,790 --> 00:04:54,260
chance to cool efficiently and so you

104
00:05:02,200 --> 00:04:57,800
have this temperature pattern that's got

105
00:05:08,220 --> 00:05:02,210
this standard shift of a hot spot nicely

106
00:05:10,560 --> 00:05:08,230
this also matched early observations of

107
00:05:15,240 --> 00:05:10,570
longitudinal structure around the planet

108
00:05:18,280 --> 00:05:15,250
so here's a classic first continuous

109
00:05:21,970 --> 00:05:18,290
orbital phase curve of thermal emission

110
00:05:24,760 --> 00:05:21,980
from the hot Jupiter and here's kind of

111
00:05:26,800 --> 00:05:24,770
the phase of the planet that we see as

112
00:05:29,470 --> 00:05:26,810
we observe the Flex from the system as a

113
00:05:31,390 --> 00:05:29,480

function of time so here's transit the

114
00:05:33,640 --> 00:05:31,400
Nightside faces us and then it turns

115
00:05:37,030 --> 00:05:33,650
around and the dayside faces us and it

116
00:05:38,440 --> 00:05:37,040
goes into eclipse behind the star if so

117
00:05:41,020 --> 00:05:38,450
this point you're just seeing stellar

118
00:05:43,840 --> 00:05:41,030
flux if you zoom in here's all the flux

119
00:05:47,860 --> 00:05:43,850
from the planet right and you see it's

120
00:05:51,090 --> 00:05:47,870
less flux here and more flux here and in

121
00:05:53,590 --> 00:05:51,100
fact the peak happens a bit before the

122
00:05:57,010 --> 00:05:53,600
secondary Eclipse and so if you

123
00:06:00,280 --> 00:05:57,020
translate flux versus orbital phase to

124
00:06:02,260 --> 00:06:00,290
flux on different longitudes of the

125
00:06:03,940 --> 00:06:02,270
planet you have that the brightest

126
00:06:07,630 --> 00:06:03,950
region of the planet is a little bit

127
00:06:09,310 --> 00:06:07,640
east of the substellar point yes this is

128
00:06:13,150 --> 00:06:09,320
what we expect this works really well

129
00:06:16,480 --> 00:06:13,160
and then there were more face curves so

130
00:06:18,450 --> 00:06:16,490
here's another one and the peaks maybe

131
00:06:21,670 --> 00:06:18,460
around the substellar point that's fine

132
00:06:23,980 --> 00:06:21,680
because right the pictures that you're

133
00:06:26,950 --> 00:06:23,990
moving this hot gas with the subsolar

134
00:06:28,660 --> 00:06:26,960
point so maybe you just have a shorter

135
00:06:30,220 --> 00:06:28,670
radius times Fiona cooling more

136
00:06:33,070 --> 00:06:30,230
efficiently you can still have this

137
00:06:35,890 --> 00:06:33,080
eastward flow it just can't move the hot

138
00:06:39,610 --> 00:06:35,900

gas as efficiently

139
00:06:42,190 --> 00:06:39,620
Micke provides a weird phase curve well

140
00:06:45,820 --> 00:06:42,200
done Nick this was a weird system both

141
00:06:50,390 --> 00:06:48,560
here's another phase curve it looks like

142
00:06:52,790 --> 00:06:50,400
it Peaks maybe around the subsolar point

143
00:06:56,200 --> 00:06:52,800
here we go peaking before picking around

144
00:06:59,390 --> 00:06:56,210
I'm sticking around peeking before cool

145
00:07:01,070 --> 00:06:59,400
right so things kind of makes sense

146
00:07:04,490 --> 00:07:01,080
we're happy with this picture that we've

147
00:07:06,980 --> 00:07:04,500
painted for ourselves about how hot

148
00:07:10,730 --> 00:07:06,990
Jupiter atmospheres and specifically

149
00:07:13,220 --> 00:07:10,740
their dynamics work and we have a bunch

150
00:07:15,590 --> 00:07:13,230
more models so this is kind of

151
00:07:20,120 --> 00:07:15,600
representative those different work by

152
00:07:23,690 --> 00:07:20,130
different groups and we all plot things

153
00:07:25,670 --> 00:07:23,700
differently but we mostly have similar

154
00:07:29,710 --> 00:07:25,680
answers where you get this eastward

155
00:07:35,540 --> 00:07:29,720
infection and so our data our models

156
00:07:37,160 --> 00:07:35,550
generally all agree and showman ample

157
00:07:40,730 --> 00:07:37,170
Bonnie even identified this nice

158
00:07:46,420 --> 00:07:40,740
physical mechanism that looks in this

159
00:07:48,440 --> 00:07:46,430
eastward jet at the equator wonderful

160
00:07:51,530 --> 00:07:48,450
until we look a little bit more closely

161
00:07:56,830 --> 00:07:51,540
so this is from this is a plot from a

162
00:08:03,590 --> 00:08:01,070
apologies from a nice recent review by

163
00:08:09,409 --> 00:08:03,600

Vivian and Ian Crossfield and it's

164
00:08:11,810 --> 00:08:09,419
showing this hot offset as a function of

165
00:08:14,210 --> 00:08:11,820
equilibrium temperature for a bunch of

166
00:08:18,050 --> 00:08:14,220
different planets observed at a bunch of

167
00:08:20,480 --> 00:08:18,060
different wavelengths and you see here's

168
00:08:24,620 --> 00:08:20,490
lots of eastward shifts positive values

169
00:08:26,060 --> 00:08:24,630
are eastward shift cool here's this is

170
00:08:29,780 --> 00:08:26,070
your troublesome data point again yeah

171
00:08:33,560 --> 00:08:29,790
okay next blame again for this but we

172
00:08:36,920 --> 00:08:33,570
have these eastward shifts okay but the

173
00:08:40,219 --> 00:08:36,930
problem is there's also this curve one

174
00:08:42,380 --> 00:08:40,229
of those viens GCMs showing a prediction

175
00:08:45,020 --> 00:08:42,390
for what the hotspot shift should

176
00:08:48,740 --> 00:08:45,030
actually be for a bunch of equilibrium

177
00:08:53,510 --> 00:08:48,750
temperature and it's rather off right

178
00:08:56,150 --> 00:08:53,520
and you may have noticed I bolded that

179
00:08:57,319 --> 00:08:56,160
this GCM has chemical equilibrium it's

180
00:09:00,439 --> 00:08:57,329
cloud lifts and

181
00:09:02,210 --> 00:09:00,449
drag-free explain that in a minute right

182
00:09:04,309 --> 00:09:02,220
but this is kind of our vanilla standard

183
00:09:07,400 --> 00:09:04,319
picture hot Jupiter it doesn't work very

184
00:09:09,410 --> 00:09:07,410
well and I'm even going to point out it

185
00:09:11,989 --> 00:09:09,420
really doesn't work well for some

186
00:09:16,009 --> 00:09:11,999
planets this one is a planet that I love

187
00:09:17,689 --> 00:09:16,019
it's unfortunately non transiting so we

188
00:09:20,660 --> 00:09:17,699

have less information about it and has

189
00:09:24,400 --> 00:09:20,670
had less observations but this planet in

190
00:09:26,600 --> 00:09:24,410
its face curve has this huge offset

191
00:09:28,729 --> 00:09:26,610
basically the hottest points around at

192
00:09:31,039 --> 00:09:28,739
the Terminator and a point that's

193
00:09:34,280 --> 00:09:31,049
missing from this is some nice work by

194
00:09:37,729 --> 00:09:34,290
Lisa ding with a planet that has a

195
00:09:40,220 --> 00:09:37,739
westward shift and I should mention

196
00:09:41,629 --> 00:09:40,230
these are all thermal emissions right so

197
00:09:44,539 --> 00:09:41,639
you might be thinking a westward shift

198
00:09:45,679 --> 00:09:44,549
in Kepler phase curves that's different

199
00:09:49,280 --> 00:09:45,689
I'll get to that in a second but these

200
00:09:52,160 --> 00:09:49,290
are all thermal emission right and so

201
00:09:54,019 --> 00:09:52,170
not only does this form of points just

202
00:09:56,030 --> 00:09:54,029
be maybe a bit lower but we're observing

203
00:10:00,710 --> 00:09:56,040
kind of even more weirdness going on

204
00:10:03,199 --> 00:10:00,720
with this planet we can also not just

205
00:10:05,600 --> 00:10:03,209
look at the phase curve offset but the

206
00:10:08,509 --> 00:10:05,610
difference in flux between the day side

207
00:10:09,949 --> 00:10:08,519
and the night side cuz these things are

208
00:10:11,960 --> 00:10:09,959
related right if you can move the

209
00:10:13,819 --> 00:10:11,970
hotspot around fairly well you can

210
00:10:18,079 --> 00:10:13,829
probably also minimize day/night

211
00:10:21,530 --> 00:10:18,089
differences and so again here's the

212
00:10:26,419 --> 00:10:21,540
vanilla prediction and it doesn't really

213
00:10:28,999 --> 00:10:26,429

work right one is a very large

214
00:10:32,479 --> 00:10:29,009
difference between the day side on the

215
00:10:36,319 --> 00:10:32,489
night side okay

216
00:10:37,939 --> 00:10:36,329
so so we have this beautiful standard

217
00:10:40,699 --> 00:10:37,949
picture of Jupiter I don't think it's

218
00:10:43,389 --> 00:10:40,709
completely wrong but I think that don't

219
00:10:46,549 --> 00:10:43,399
quite have things that's owned up as

220
00:10:48,859 --> 00:10:46,559
maybe some people perceive and by people

221
00:10:50,539 --> 00:10:48,869
I mean the people who say why why pretty

222
00:10:52,429 --> 00:10:50,549
study hot Jupiters anymore time chart

223
00:10:57,470 --> 00:10:52,439
you know what's going on no there's more

224
00:11:01,189 --> 00:10:57,480
to learn it's not within my title slide

225
00:11:04,189 --> 00:11:01,199
of physical things to talk about I'm not

226
00:11:07,819 --> 00:11:04,199
going to spend time talking about what

227
00:11:09,470 --> 00:11:07,829
if it's aren't incrementation rates that

228
00:11:11,690 --> 00:11:09,480
can affect what

229
00:11:15,170 --> 00:11:11,700
circulation and I'm also going to want

230
00:11:19,280 --> 00:11:15,180
to talk about what if their rotation

231
00:11:21,290 --> 00:11:19,290
axis has some nonzero Blakely but these

232
00:11:29,990 --> 00:11:21,300
are also other things that can make

233
00:11:31,520 --> 00:11:30,000
circulation okay so even if I made this

234
00:11:32,810 --> 00:11:31,530
point at the beginning but this is the

235
00:11:35,450 --> 00:11:32,820
wrong way to think about it I'm gonna

236
00:11:37,730 --> 00:11:35,460
start by ignoring chemistry and clouds

237
00:11:41,420 --> 00:11:37,740
for a second and just thinking about

238
00:11:44,180 --> 00:11:41,430

dynamics right so within this context

239
00:11:46,370 --> 00:11:44,190
right so far been ignoring chemistry and

240
00:11:48,710 --> 00:11:46,380
clouds for the standard picture of hot

241
00:11:50,510 --> 00:11:48,720
Jupiters within this context what else

242
00:11:55,040 --> 00:11:50,520
could be going on just with the dynamics

243
00:11:59,180 --> 00:11:55,050
that doesn't quite make sense well here

244
00:12:00,860 --> 00:11:59,190
we come back to that drag-free that was

245
00:12:04,190 --> 00:12:00,870
in the vanilla version of the hot

246
00:12:07,280 --> 00:12:04,200
Jupiters here's those same plots again

247
00:12:11,660 --> 00:12:07,290
but now in these GCM this time from

248
00:12:14,120 --> 00:12:11,670
Tad's there's been this Bragg timescale

249
00:12:17,270 --> 00:12:14,130
so there's something slowing down the

250
00:12:21,380 --> 00:12:17,280
winds on some timescale and you can play

251
00:12:23,240 --> 00:12:21,390
with that value and these lines maybe

252
00:12:26,240 --> 00:12:23,250
match the data a little bit better and

253
00:12:28,280 --> 00:12:26,250
they're implying that the circulation is

254
00:12:30,530 --> 00:12:28,290
not as efficient as we might think

255
00:12:33,860 --> 00:12:30,540
right there's something that's

256
00:12:36,680 --> 00:12:33,870
preventing transport of heat around the

257
00:12:38,750 --> 00:12:36,690
planet and keeping these values closer

258
00:12:40,990 --> 00:12:38,760
to one keeping a larger day-night

259
00:12:43,190 --> 00:12:41,000
difference right and similarly

260
00:12:44,390 --> 00:12:43,200
preventing the hotspot from the thing

261
00:12:48,950 --> 00:12:44,400
that's far away from the substellar

262
00:12:52,310 --> 00:12:48,960
point and this drag is a proxy for the

263
00:12:55,490 --> 00:12:52,320

very unfortunate complicating fact that

264
00:12:58,730 --> 00:12:55,500
these planets magnetic effects might

265
00:13:04,490 --> 00:12:58,740
matter and in really gross disgusting

266
00:13:07,610 --> 00:13:04,500
horrible smaadahl ways so before we

267
00:13:10,010 --> 00:13:07,620
heard about magnetic effects mattering

268
00:13:13,300 --> 00:13:10,020
great deep in Jupiter right and slowing

269
00:13:16,850 --> 00:13:13,310
winds down there this is a different

270
00:13:19,820 --> 00:13:16,860
context but similar idea right

271
00:13:22,670 --> 00:13:19,830
the reason it's a very different context

272
00:13:23,180 --> 00:13:22,680
is that you're not moving to a region

273
00:13:25,880 --> 00:13:23,190
that think

274
00:13:27,830 --> 00:13:25,890
creasing the homogenized and where

275
00:13:29,900 --> 00:13:27,840
you're getting metallic hydrogen here

276
00:13:31,640 --> 00:13:29,910
your ionization is coming from the fact

277
00:13:35,180 --> 00:13:31,650
that the atmosphere is so hot that

278
00:13:37,070 --> 00:13:35,190
you're starting to kick off electrons

279
00:13:40,160 --> 00:13:37,080
you've got thermal ionization going on

280
00:13:42,260 --> 00:13:40,170
so you have these charges embedded in

281
00:13:45,050 --> 00:13:42,270
winds that are blowing around the planet

282
00:13:46,850 --> 00:13:45,060
the planet has a magnetic field I hear

283
00:13:48,770 --> 00:13:46,860
tell charges don't like to move through

284
00:13:50,780 --> 00:13:48,780
magnetic field so there's a back

285
00:13:55,670 --> 00:13:50,790
reaction on the winds that acts to slow

286
00:13:57,860 --> 00:13:55,680
them down but even though we did some

287
00:14:00,770 --> 00:13:57,870
timescale estimates long ago it's not a

288
00:14:03,170 --> 00:14:00,780

drag timescale right and these are

289
00:14:04,730 --> 00:14:03,180
actually plots of estimates of some

290
00:14:07,520 --> 00:14:04,740
magnetic timescale at a couple different

291
00:14:11,180 --> 00:14:07,530
locations in the atmosphere and this is

292
00:14:14,150 --> 00:14:11,190
the log of the time scale so between the

293
00:14:16,130 --> 00:14:14,160
dayside where you have very short time

294
00:14:18,590 --> 00:14:16,140
fields it's really hot ionization should

295
00:14:22,550 --> 00:14:18,600
matter a lot and the Nightside where you

296
00:14:25,190 --> 00:14:22,560
have basically infinite time scale it's

297
00:14:26,780 --> 00:14:25,200
messy and it changes at different depths

298
00:14:28,550 --> 00:14:26,790
from the atmosphere it's inherently

299
00:14:32,090 --> 00:14:28,560
three-dimensional it's just disgusting

300
00:14:36,020 --> 00:14:32,100
it's really gross there are a few brave

301
00:14:39,260 --> 00:14:36,030
souls working on doing what's inherently

302
00:14:41,360 --> 00:14:39,270
non ideal MHD to model the atomic

303
00:14:49,040 --> 00:14:41,370
spheres correctly and we should fund

304
00:14:52,820 --> 00:14:49,050
them more a recent example of MHD

305
00:14:55,730 --> 00:14:52,830
modeling of hot jupiter atmospheres is

306
00:14:58,100 --> 00:14:55,740
this work which i think is actually a

307
00:15:00,950 --> 00:14:58,110
shallow model so it's very hard to do it

308
00:15:03,950 --> 00:15:00,960
all right but here's the flow pattern

309
00:15:06,350 --> 00:15:03,960
you get without any magnetic effects

310
00:15:09,020 --> 00:15:06,360
they turn on some magnetic effects

311
00:15:10,550 --> 00:15:09,030
that's what this thing means and instead

312
00:15:14,590 --> 00:15:10,560
they've restricted the circulation

313
00:15:17,120 --> 00:15:14,600

pattern in its westward now in this work

314
00:15:21,380 --> 00:15:17,130
from these kind of scaling estimates

315
00:15:22,820 --> 00:15:21,390
they said cool but that weird planet

316
00:15:25,850 --> 00:15:22,830
that I pointed out before with the

317
00:15:30,110 --> 00:15:25,860
westward shift you would need like three

318
00:15:32,390 --> 00:15:30,120
K three kilogauss to produce this

319
00:15:35,540 --> 00:15:32,400
according to their scaling so problem

320
00:15:38,630 --> 00:15:35,550
far from solved

321
00:15:40,370 --> 00:15:38,640
um here's where I suck to reach the

322
00:15:42,320 --> 00:15:40,380
point that I realized I had too much to

323
00:15:44,770 --> 00:15:42,330
talk about and Simon's apologize for

324
00:15:47,810 --> 00:15:44,780
some bullet point lists of things but

325
00:15:50,180 --> 00:15:47,820
aside from this gross magnetic stuff but

326
00:15:52,610 --> 00:15:50,190
if you move to the cooler hot Jupiter

327
00:15:54,350 --> 00:15:52,620
where my net effects shouldn't matter

328
00:15:56,450 --> 00:15:54,360
you can still worry about whether we're

329
00:15:59,840 --> 00:15:56,460
getting the standard picture correct in

330
00:16:02,780 --> 00:15:59,850
terms of dynamics there's been recent

331
00:16:05,000 --> 00:16:02,790
work looking at actually with the

332
00:16:06,890 --> 00:16:05,010
dynamical mechanism that we have in our

333
00:16:10,090 --> 00:16:06,900
standard picture thinking more about

334
00:16:12,440 --> 00:16:10,100
sub-grid physics our transonic flows

335
00:16:14,000 --> 00:16:12,450
shocks may matter but maybe not that

336
00:16:18,830 --> 00:16:14,010
much actually it turns out surprisingly

337
00:16:22,310 --> 00:16:18,840
maybe and also thinking about depth of

338
00:16:24,230 --> 00:16:22,320

jets and directions of circulation so I

339
00:16:26,410 --> 00:16:24,240
can't talk about them but go look at

340
00:16:32,300 --> 00:16:28,880
however I'm also gonna highlight a

341
00:16:35,210 --> 00:16:32,310
couple more papers that specifically are

342
00:16:38,090 --> 00:16:35,220
thinking about within this context of

343
00:16:40,220 --> 00:16:38,100
the hot jupiter dynamics what are the

344
00:16:42,650 --> 00:16:40,230
implications for how things are mixed

345
00:16:44,270 --> 00:16:42,660
around because this is a moving us more

346
00:16:46,220 --> 00:16:44,280
in the direction of what's going on with

347
00:16:48,590 --> 00:16:46,230
the chemistry in clouds right and so

348
00:16:50,840 --> 00:16:48,600
thinking about dynamics how we're

349
00:16:52,430 --> 00:16:50,850
thinking about it how to assess what the

350
00:16:54,680 --> 00:16:52,440
mixing between different regions is

351
00:16:58,520 --> 00:16:54,690
because as most of the rest of the talk

352
00:17:00,800 --> 00:16:58,530
will talk about I will talk about this

353
00:17:05,990 --> 00:17:00,810
matters a lot for the chemistry and

354
00:17:08,600 --> 00:17:06,000
cloud so getting into the chemistry now

355
00:17:09,530 --> 00:17:08,610
we've moved back to this context for all

356
00:17:13,130 --> 00:17:09,540
the things matter

357
00:17:14,810 --> 00:17:13,140
I will also I'm not going to talk

358
00:17:19,490 --> 00:17:14,820
as much about the connection between

359
00:17:22,850 --> 00:17:19,500
chemistry and clouds because I have this

360
00:17:24,260 --> 00:17:22,860
three dimensional bias but on a local

361
00:17:26,570 --> 00:17:24,270
scale of course your chemistry in your

362
00:17:29,150 --> 00:17:26,580
clouds and form each other what exists

363
00:17:31,250 --> 00:17:29,160

what can form if something rains out

364
00:17:33,950 --> 00:17:31,260
because the cloud formed them that also

365
00:17:36,320 --> 00:17:33,960
changes your chemistry so that's as much

366
00:17:40,490 --> 00:17:36,330
as I'm going to say about the cherem but

367
00:17:42,590 --> 00:17:40,500
let's talk about this a bit more so

368
00:17:46,550 --> 00:17:42,600
again it's been recognized for quite a

369
00:17:47,580 --> 00:17:46,560
while that dynamic can actually probably

370
00:17:49,680 --> 00:17:47,590
should

371
00:17:53,160 --> 00:17:49,690
bring things out of local chemical

372
00:17:56,280 --> 00:17:53,170
equilibrium which is to say that if you

373
00:17:58,980 --> 00:17:56,290
take a temperature field for a planet

374
00:18:01,110 --> 00:17:58,990
and based on the local temperature and

375
00:18:03,930 --> 00:18:01,120
pressure conditions try to figure out

376
00:18:07,110 --> 00:18:03,940
what should exist there then as we

377
00:18:09,090 --> 00:18:07,120
learned from jameelah we have methane

378
00:18:12,000 --> 00:18:09,100
where it's cold and we have carbon

379
00:18:14,220 --> 00:18:12,010
monoxide where it's hot the problem is

380
00:18:16,020 --> 00:18:14,230
that if you add something very simple in

381
00:18:19,110 --> 00:18:16,030
your model to let there be a conversion

382
00:18:21,180 --> 00:18:19,120
between these two with the dynamics then

383
00:18:23,100 --> 00:18:21,190
it looks like there's an asymmetry but

384
00:18:25,170 --> 00:18:23,110
actually just look at the scale here you

385
00:18:28,050 --> 00:18:25,180
get carbon monoxide everywhere in this

386
00:18:31,290 --> 00:18:28,060
law similarly you can have vertical

387
00:18:33,330 --> 00:18:31,300
mixing so this is an example as a

388
00:18:37,050 --> 00:18:33,340

function of pressure of the amount of

389
00:18:38,670 --> 00:18:37,060
methane on a hot Jupiters day sign so

390
00:18:41,400 --> 00:18:38,680
taking the temperature profile on the

391
00:18:43,440 --> 00:18:41,410
day side and if you have equilibrium you

392
00:18:45,630 --> 00:18:43,450
get this blue curve right here right it

393
00:18:47,430 --> 00:18:45,640
drops off we just said that you should

394
00:18:50,240 --> 00:18:47,440
have carbon monoxide and stay on the day

395
00:18:52,890 --> 00:18:50,250
side but if you allow there to be

396
00:18:55,110 --> 00:18:52,900
vertical mixing you can have the

397
00:18:57,360 --> 00:18:55,120
quenching effect where you in fact

398
00:18:59,700 --> 00:18:57,370
maintain a lot of methane oops forgot

399
00:19:06,810 --> 00:18:59,710
about the photon photo chemistry matters

400
00:19:09,930 --> 00:19:06,820
two strik II more recently people are

401
00:19:11,760 --> 00:19:09,940
continuing to revisit this and try to do

402
00:19:14,760 --> 00:19:11,770
it in a little bit more detail kind of

403
00:19:19,680 --> 00:19:14,770
tracing chemical conversions with the

404
00:19:22,860 --> 00:19:19,690
dynamics so here's an example of four

405
00:19:24,810 --> 00:19:22,870
different major species looking as a

406
00:19:27,990 --> 00:19:24,820
function of pressure how much there is

407
00:19:30,060 --> 00:19:28,000
and these blobs of lines are actually

408
00:19:33,630 --> 00:19:30,070
four different regions around the planet

409
00:19:37,500 --> 00:19:33,640
you can see high in the atmosphere quite

410
00:19:40,320 --> 00:19:37,510
a lot of dirtville variation right on to

411
00:19:42,450 --> 00:19:40,330
the planet and it gets less variation as

412
00:19:43,830 --> 00:19:42,460
homogenize deeper down and the four

413
00:19:48,560 --> 00:19:43,840

different plots are four different

414
00:19:50,850 --> 00:19:48,570
assumptions about whether the planet has

415
00:19:55,080 --> 00:19:50,860
stratosphere or not and what the carbon

416
00:19:57,270 --> 00:19:55,090
oxygen ratio is all of these then

417
00:20:00,540 --> 00:19:57,280
influence what's going on in terms of

418
00:20:01,720 --> 00:20:00,550
the chemistry it's also worth noting

419
00:20:03,340 --> 00:20:01,730
that we need to be really care

420
00:20:05,769 --> 00:20:03,350
all about calculating chemical

421
00:20:07,960 --> 00:20:05,779
equilibrium actually chemistry is hard

422
00:20:11,950 --> 00:20:07,970
last time I took it was in high school

423
00:20:14,830 --> 00:20:11,960
but it's tricky it's tricky it's

424
00:20:18,009 --> 00:20:14,840
complicated and so people are also going

425
00:20:20,320 --> 00:20:18,019
to try to improve how we're modeling the

426
00:20:22,470 --> 00:20:20,330
chemistry and the asama spheres which is

427
00:20:24,789 --> 00:20:22,480
very important if we want to talk about

428
00:20:30,789 --> 00:20:24,799
equilibrium or disequilibrium or just

429
00:20:34,950 --> 00:20:30,799
what species to accept also if the

430
00:20:37,960 --> 00:20:34,960
chemistry is not equilibrium then the

431
00:20:40,000 --> 00:20:37,970
opacities crowd the atmosphere change

432
00:20:43,090 --> 00:20:40,010
right it's the species that are

433
00:20:46,870 --> 00:20:43,100
providing opacity so if you change what

434
00:20:50,139 --> 00:20:46,880
exists where that means it changes how

435
00:20:53,379 --> 00:20:50,149
far into the atmosphere you see so this

436
00:20:55,750 --> 00:20:53,389
is a lovely example of that results from

437
00:20:58,690 --> 00:20:55,760
a three-dimensional model choking as a

438
00:21:02,139 --> 00:20:58,700

function of pressure and now longitude

439
00:21:04,659 --> 00:21:02,149
around the planet the contribution

440
00:21:07,180 --> 00:21:04,669
function so where it's very dark that's

441
00:21:10,149 --> 00:21:07,190
mainly the region that we're seeing I

442
00:21:11,740 --> 00:21:10,159
think yeah 8 microns sister band right

443
00:21:14,440 --> 00:21:11,750
and then these are lines of temperature

444
00:21:16,870 --> 00:21:14,450
on top so if you compare a model that

445
00:21:19,480 --> 00:21:16,880
assumes chemical equilibrium to one that

446
00:21:21,730 --> 00:21:19,490
uses a scheme to let the chemistry come

447
00:21:24,730 --> 00:21:21,740
out of equilibrium you may notice the

448
00:21:26,019 --> 00:21:24,740
temperature lines the numbers are a

449
00:21:27,789 --> 00:21:26,029
little bit different the pattern doesn't

450
00:21:30,220 --> 00:21:27,799
look that different but the contribution

451
00:21:33,580 --> 00:21:30,230
function now is different right there's

452
00:21:35,830 --> 00:21:33,590
kind of this up/down slide up again

453
00:21:38,710 --> 00:21:35,840
where's this it's just kind of this way

454
00:21:41,080 --> 00:21:38,720
right so changing the chemistry changes

455
00:21:43,870 --> 00:21:41,090
what part of the atmosphere we're seeing

456
00:21:48,100 --> 00:21:43,880
in our observations and so maybe how we

457
00:21:50,409 --> 00:21:48,110
interpret them to because these of

458
00:21:53,049 --> 00:21:50,419
Hasse's are changing that also means

459
00:21:55,210 --> 00:21:53,059
that the actual physical heating of the

460
00:21:57,460 --> 00:21:55,220
atmosphere is changing and it's a

461
00:22:01,330 --> 00:21:57,470
differential eating that drives dynamics

462
00:22:03,490 --> 00:22:01,340
and so if you're changing in a spatially

463
00:22:05,680 --> 00:22:03,500

in homogeneous way how you're heating

464
00:22:09,039 --> 00:22:05,690
the atmosphere this consequences from

465
00:22:11,110 --> 00:22:09,049
your day next so for example here's some

466
00:22:13,509 --> 00:22:11,120
more recent work saying let's just

467
00:22:14,770 --> 00:22:13,519
assume something about the chemistry and

468
00:22:17,050 --> 00:22:14,780
therefore opacity

469
00:22:19,870 --> 00:22:17,060
and the atmosphere maybe it's mostly

470
00:22:22,690 --> 00:22:19,880
carbon monoxide or mostly methane and

471
00:22:25,320 --> 00:22:22,700
these are Delta temperatures at a couple

472
00:22:28,450 --> 00:22:25,330
different height in the atmosphere

473
00:22:30,340 --> 00:22:28,460
between I think this is between a

474
00:22:31,750 --> 00:22:30,350
chemical equilibrium model and these two

475
00:22:33,370 --> 00:22:31,760
different models and so you end up

476
00:22:35,290 --> 00:22:33,380
resulting in different temperature

477
00:22:37,780 --> 00:22:35,300
structures because you've changed how

478
00:22:42,940 --> 00:22:37,790
you keep yes because of chemical

479
00:22:47,170 --> 00:22:42,950
disequilibrium in an extreme example for

480
00:22:49,120 --> 00:22:47,180
these ultra hot Jupiters they're

481
00:22:51,970 --> 00:22:49,130
terrifying not just because they're

482
00:22:54,310 --> 00:22:51,980
magnetic but also because on the bay

483
00:22:56,290 --> 00:22:54,320
side it's hot enough that you actually

484
00:22:58,440 --> 00:22:56,300
should probably dissociate your

485
00:23:01,690 --> 00:22:58,450
molecular hydrogen into atomic hydrogen

486
00:23:05,170 --> 00:23:01,700
this is a huge change in the most

487
00:23:07,260 --> 00:23:05,180
abundant molecule in the atmosphere and

488
00:23:10,540 --> 00:23:07,270

this can have important consequences

489
00:23:14,080 --> 00:23:10,550
from an energetic perspective the

490
00:23:18,790 --> 00:23:14,090
dynamics perspective and so this I think

491
00:23:21,700 --> 00:23:18,800
was a research note yeah we're kind of

492
00:23:25,350 --> 00:23:21,710
trying to put some initial effects from

493
00:23:28,270 --> 00:23:25,360
this dissociation and the heat

494
00:23:31,420 --> 00:23:28,280
associated with the dissociation

495
00:23:33,610 --> 00:23:31,430
recombination and looking again at this

496
00:23:35,800 --> 00:23:33,620
day/night contrast as a function of the

497
00:23:37,480 --> 00:23:35,810
equilibrium temperature and so these

498
00:23:40,270 --> 00:23:37,490
different colors are you know without

499
00:23:41,410 --> 00:23:40,280
drag with frags as we think things don't

500
00:23:44,800 --> 00:23:41,420
work how we think they should

501
00:23:46,990 --> 00:23:44,810
and now the dotted lines are the

502
00:23:48,610 --> 00:23:47,000
original country you don't have any

503
00:23:52,810 --> 00:23:48,620
dissociation and the psalm lines are

504
00:23:55,360 --> 00:23:52,820
trying to include proxy for that

505
00:23:57,400 --> 00:23:55,370
dissociation and what that's gone so

506
00:23:58,720 --> 00:23:57,410
ultra hot Jupiters I know observers love

507
00:24:00,580 --> 00:23:58,730
them because they're so bright and

508
00:24:08,620 --> 00:24:00,590
wonderful they're terrifying from a

509
00:24:12,310 --> 00:24:08,630
theory perspective okay so Klaus you

510
00:24:14,980 --> 00:24:12,320
know Hayes's because I have been well

511
00:24:16,750 --> 00:24:14,990
taught to think about aerosol which I'm

512
00:24:18,850 --> 00:24:16,760
sure Sarah will do her soapbox for us

513
00:24:20,080 --> 00:24:18,860

again but they could be clouds or

514
00:24:23,800 --> 00:24:20,090
Hayes's and in many cases we don't

515
00:24:26,270 --> 00:24:23,810
actually know my title hood clouds and

516
00:24:28,400 --> 00:24:26,280
for people if they're focusing on clouds

517
00:24:30,500 --> 00:24:28,410
because there may be easier I'm gonna

518
00:24:31,820 --> 00:24:30,510
but we'll hear more about Jesus from

519
00:24:33,920 --> 00:24:31,830
Sarah and then of course I want to

520
00:24:35,150 --> 00:24:33,930
recognize we have a whole session about

521
00:24:36,590 --> 00:24:35,160
clouds later and we're even going to

522
00:24:37,690 --> 00:24:36,600
hear some more about how Jupiter clouds

523
00:24:41,360 --> 00:24:37,700
again later

524
00:24:43,340 --> 00:24:41,370
but within here let's really focus again

525
00:24:44,450 --> 00:24:43,350
how this interacts in a

526
00:24:46,360 --> 00:24:44,460
three-dimensional sense with the

527
00:24:49,940 --> 00:24:46,370
dynamics

528
00:24:52,010 --> 00:24:49,950
okay so observational evidence for

529
00:24:54,050 --> 00:24:52,020
aerosols usually means showing David

530
00:24:58,100 --> 00:24:54,060
sings lovely plot with all the different

531
00:25:02,210 --> 00:24:58,110
hot Jupiter cetera and that's true in a

532
00:25:04,610 --> 00:25:02,220
3d sense I'm dead so one of the first

533
00:25:06,890 --> 00:25:04,620
examples with invoking clouds I've

534
00:25:08,480 --> 00:25:06,900
noticed this very on trend to invoke

535
00:25:13,490 --> 00:25:08,490
clouds if you don't know what's going on

536
00:25:16,280 --> 00:25:13,500
with your observation so this is lost 43

537
00:25:18,290 --> 00:25:16,290
I showed this face curve earlier with

538
00:25:19,850 --> 00:25:18,300

the whole plethora of other ones but if

539
00:25:23,090 --> 00:25:19,860
you notice a little bit more carefully

540
00:25:26,690 --> 00:25:23,100
the flux from when the night side of the

541
00:25:29,090 --> 00:25:26,700
planet is facing us is basically the

542
00:25:31,550 --> 00:25:29,100
same as during secondary Eclipse which

543
00:25:32,870 --> 00:25:31,560
means you're just seeing the star which

544
00:25:35,420 --> 00:25:32,880
means you're not getting a mission from

545
00:25:37,430 --> 00:25:35,430
the night side right I'm picking on this

546
00:25:39,350 --> 00:25:37,440
and so this is a general theme that we

547
00:25:41,900 --> 00:25:39,360
looked at before in the population of

548
00:25:43,790 --> 00:25:41,910
planets that there's a very large

549
00:25:46,310 --> 00:25:43,800
difference in flux between the day and

550
00:25:49,010 --> 00:25:46,320
night side for many planets and so you

551
00:25:52,100 --> 00:25:49,020
can say ah just put some clouds on the

552
00:25:57,440 --> 00:25:52,110
cold night side and then it's dim and it

553
00:26:03,290 --> 00:25:57,450
works right maybe I also really like

554
00:26:07,130 --> 00:26:03,300
this data set which is Kepler so this is

555
00:26:09,410 --> 00:26:07,140
reflected light and here the phase curve

556
00:26:12,620 --> 00:26:09,420
happens the peak of the phase curve

557
00:26:15,440 --> 00:26:12,630
happens after secondary Eclipse which

558
00:26:18,220 --> 00:26:15,450
means the brightest reflected region is

559
00:26:20,900 --> 00:26:18,230
west of the substellar point

560
00:26:23,870 --> 00:26:20,910
okay so if we think about our standard

561
00:26:26,420 --> 00:26:23,880
picture of hot Jupiters right we have

562
00:26:29,090 --> 00:26:26,430
this eastward jet going around the

563
00:26:32,510 --> 00:26:29,100

equator and a hot day side a cooler

564
00:26:34,640 --> 00:26:32,520
night side and so if you bring some of

565
00:26:38,630 --> 00:26:34,650
this hot gas around onto the night side

566
00:26:39,869 --> 00:26:38,640
it cools forms clouds but you still have

567
00:26:41,430 --> 00:26:39,879
this eastward most

568
00:26:44,819 --> 00:26:41,440
and so it's gonna bring some of those

569
00:26:46,589 --> 00:26:44,829
clouds around to the day side and then

570
00:26:48,329 --> 00:26:46,599
they'll dissipate but you might have

571
00:26:50,759 --> 00:26:48,339
some clouds hanging out on the western

572
00:26:53,759 --> 00:26:50,769
side of the planet causing some enhanced

573
00:26:55,829 --> 00:26:53,769
reflection see this fancy picture of hot

574
00:26:58,049 --> 00:26:55,839
Jupiters is really nice I just think

575
00:27:00,689 --> 00:26:58,059
it's not fully complete yet but it kind

576
00:27:03,739 --> 00:27:00,699
of makes sense it's not ridiculous to

577
00:27:08,069 --> 00:27:03,749
say that this might be what's going on

578
00:27:10,499 --> 00:27:08,079
okay so dynamics controls where clouds

579
00:27:14,009 --> 00:27:10,509
form right you need the right conditions

580
00:27:18,180 --> 00:27:14,019
for clouds to form but that's not enough

581
00:27:19,739 --> 00:27:18,190
this is a beautiful cross section from

582
00:27:22,079 --> 00:27:19,749
one of phidian's paper system I included

583
00:27:24,359 --> 00:27:22,089
the ice and how to spell your name and

584
00:27:26,519 --> 00:27:24,369
this is showing the temperature

585
00:27:29,099 --> 00:27:26,529
throughout a three-dimensional model and

586
00:27:33,329 --> 00:27:29,109
here it's being sliced along the

587
00:27:36,149 --> 00:27:33,339
Terminator the day-night boundary this

588
00:27:40,379 --> 00:27:36,159

is the North Pole the South Pole this is

589
00:27:44,039 --> 00:27:40,389
the east side and the west side and this

590
00:27:48,419 --> 00:27:44,049
side hotter so I guess the substrate

591
00:27:51,389 --> 00:27:48,429
points taping up yes okay so you can see

592
00:27:53,879 --> 00:27:51,399
here's the hot gas that's blowing to the

593
00:27:55,919 --> 00:27:53,889
night side from the deicide and here's

594
00:27:57,930 --> 00:27:55,929
cooler gas that's coming from the cool

595
00:28:01,819 --> 00:27:57,940
night side toilet if we're looking the

596
00:28:06,059 --> 00:28:01,829
day side and on top of this are plotted

597
00:28:07,339 --> 00:28:06,069
condensation curves for a few different

598
00:28:11,699 --> 00:28:07,349
species

599
00:28:13,379 --> 00:28:11,709
notice it's mineral and metallic dust

600
00:28:17,430 --> 00:28:13,389
that forms clouds on hunt you butter

601
00:28:20,909 --> 00:28:17,440
here and I like this way of showing the

602
00:28:23,239 --> 00:28:20,919
condensation curves because it's showing

603
00:28:28,049 --> 00:28:23,249
that the cause are regional effects

604
00:28:31,349 --> 00:28:28,059
right very spatially in homogeneous and

605
00:28:34,049 --> 00:28:31,359
also for clouds to exist you need to

606
00:28:37,079 --> 00:28:34,059
take the material that has these species

607
00:28:39,569 --> 00:28:37,089
and to pull it across the condensation

608
00:28:41,729 --> 00:28:39,579
curve so that it can form a cloud right

609
00:28:46,199 --> 00:28:41,739
I don't do clouds so if my simple

610
00:28:47,639 --> 00:28:46,209
understanding of it so there are people

611
00:28:50,309 --> 00:28:47,649
who do do clouds and are trying to do a

612
00:28:51,659 --> 00:28:50,319
more complex version of it and so within

613
00:28:53,289 --> 00:28:51,669

this context where you have very

614
00:28:56,230 --> 00:28:53,299
spatially

615
00:28:58,600 --> 00:28:56,240
in homogeneous conditions you can take

616
00:29:01,419 --> 00:28:58,610
kind of profiles at different regions

617
00:29:04,389 --> 00:29:01,429
around the planet and you can say let's

618
00:29:10,649 --> 00:29:04,399
think about the timescales as a function

619
00:29:13,269 --> 00:29:10,659
of pressure right for material growing

620
00:29:15,130 --> 00:29:13,279
nucleating sinking let's also think

621
00:29:17,590 --> 00:29:15,140
about what's going on in terms of both

622
00:29:19,899 --> 00:29:17,600
the horizontal and vertical mixing

623
00:29:23,889 --> 00:29:19,909
that's helping this stuff grow or not

624
00:29:25,899 --> 00:29:23,899
and move and you can kind of do these

625
00:29:27,159 --> 00:29:25,909
more detailed calculations using cloud

626
00:29:29,440 --> 00:29:27,169
microphysics you try to figure out

627
00:29:34,690 --> 00:29:29,450
what's actually going on and you can get

628
00:29:37,330 --> 00:29:34,700
things like the distribution of a couple

629
00:29:40,720 --> 00:29:37,340
different kinds of clouds as a function

630
00:29:44,830 --> 00:29:40,730
of the particle radius add a couple

631
00:29:46,210 --> 00:29:44,840
different pressures and it's it's

632
00:29:48,720 --> 00:29:46,220
wonderful thank you for doing these

633
00:29:52,360 --> 00:29:48,730
calculations but it's complicated right

634
00:29:54,370 --> 00:29:52,370
you have these really weird distribution

635
00:29:58,029 --> 00:29:54,380
of particle radii it depends on your

636
00:30:00,519 --> 00:29:58,039
pressure this is at one location right

637
00:30:02,289 --> 00:30:00,529
it's very complicated and it's very

638
00:30:04,779 --> 00:30:02,299

complicated in part because you have

639
00:30:07,090 --> 00:30:04,789
these really complex structures because

640
00:30:12,370 --> 00:30:07,100
you have this day/night forcing and

641
00:30:14,409 --> 00:30:12,380
their spawning dynamics also the clouds

642
00:30:16,450 --> 00:30:14,419
don't just exist because of the dynamics

643
00:30:19,840 --> 00:30:16,460
of clouds then also feed back onto the

644
00:30:23,380 --> 00:30:19,850
dynamics right so here's a very pretty

645
00:30:26,409 --> 00:30:23,390
plots showing within a 3d model that

646
00:30:28,840 --> 00:30:26,419
Michael Roman did what's the

647
00:30:31,720 --> 00:30:28,850
distribution of some of these different

648
00:30:34,500 --> 00:30:31,730
species look like and then what the

649
00:30:37,360 --> 00:30:34,510
total cloud reflection on the dayside is

650
00:30:38,680 --> 00:30:37,370
right and one thing to notice is that

651
00:30:40,269 --> 00:30:38,690
first of all of course different species

652
00:30:43,360 --> 00:30:40,279
exists different locations but

653
00:30:45,730 --> 00:30:43,370
especially with whatever this thing is

654
00:30:47,860 --> 00:30:45,740
called this species there's this

655
00:30:50,049 --> 00:30:47,870
patchiness on the dayside and as this

656
00:30:52,149 --> 00:30:50,059
passion is on the dayside because

657
00:30:55,419 --> 00:30:52,159
there's this radiative feedback that

658
00:30:59,380 --> 00:30:55,429
exists where when you form a cloud now

659
00:31:01,029 --> 00:30:59,390
it becomes more reflective and connects

660
00:31:03,909 --> 00:31:01,039
more absorption properties too so it's

661
00:31:06,310 --> 00:31:03,919
changing the light that's coming in to

662
00:31:08,230 --> 00:31:06,320
warm the planet in the first place as

663
00:31:11,350 --> 00:31:08,240

the ability of the planet to them at

664
00:31:13,840 --> 00:31:11,360
thermal radiation and so this changes

665
00:31:16,330 --> 00:31:13,850
the temperature structure and so then

666
00:31:18,519 --> 00:31:16,340
the clouds may dissipate right see you

667
00:31:20,139 --> 00:31:18,529
it works both ways you form the clouds

668
00:31:23,860 --> 00:31:20,149
and then also the clouds can form the

669
00:31:27,879 --> 00:31:23,870
dynamics and the 3d structure this is

670
00:31:31,210 --> 00:31:27,889
another example of a 3d model with some

671
00:31:34,299 --> 00:31:31,220
clouds included that have seen back onto

672
00:31:37,720 --> 00:31:34,309
the circulation and it's wonderful and

673
00:31:41,080 --> 00:31:37,730
terrifying and I say that because here

674
00:31:44,230 --> 00:31:41,090
is a plot showing the flux from the

675
00:31:47,409 --> 00:31:44,240
planet so here's our eastward shift

676
00:31:49,090 --> 00:31:47,419
isn't it beautiful little patch here

677
00:31:51,220 --> 00:31:49,100
then were you stupid film this nice

678
00:31:54,730 --> 00:31:51,230
eastward shift here's the clouds that

679
00:31:59,110 --> 00:31:54,740
exist in the atmosphere and then 24

680
00:32:03,220 --> 00:31:59,120
hours on this planet later here's what

681
00:32:05,519 --> 00:32:03,230
the flux looks like and as different

682
00:32:11,340 --> 00:32:05,529
write something that's convertibility

683
00:32:14,860 --> 00:32:11,350
because you have these clouds sorry hmm

684
00:32:17,639 --> 00:32:14,870
okay so I think I have a little bit of

685
00:32:19,509 --> 00:32:17,649
time left so I'm going to try

686
00:32:21,190 --> 00:32:19,519
recognizing that I'm biased towards

687
00:32:22,360 --> 00:32:21,200
theory and so most of those papers were

688
00:32:24,879 --> 00:32:22,370

very theoretical

689
00:32:26,649 --> 00:32:24,889
how can observations help us try to

690
00:32:30,730 --> 00:32:26,659
understand more right we have some

691
00:32:32,889 --> 00:32:30,740
observations that led us to think that

692
00:32:35,740 --> 00:32:32,899
maybe our standard picture of hot

693
00:32:37,779 --> 00:32:35,750
Jupiter needs revision how can we do a

694
00:32:41,649 --> 00:32:37,789
bit better and of course the requisite

695
00:32:46,840 --> 00:32:41,659
answers are space missions and extremely

696
00:32:48,840 --> 00:32:46,850
large telescopes and there's kind of

697
00:32:52,720 --> 00:32:48,850
some obvious consequences from this

698
00:32:55,480 --> 00:32:52,730
which we're also mentioned Sarah kept

699
00:32:58,210 --> 00:32:55,490
calling out the need for spectroscopy so

700
00:33:00,070 --> 00:32:58,220
photometry spectroscopy is great right

701
00:33:01,450 --> 00:33:00,080
and spectroscopy at the longer

702
00:33:04,690 --> 00:33:01,460
wavelengths that we're gonna get from

703
00:33:06,639 --> 00:33:04,700
these missions is going to inform us of

704
00:33:09,310 --> 00:33:06,649
what's going on with some of the species

705
00:33:11,259 --> 00:33:09,320
that we're really curious about right it

706
00:33:12,909 --> 00:33:11,269
may also help inform what's going on

707
00:33:15,580 --> 00:33:12,919
with some of the clouds if we can

708
00:33:17,180 --> 00:33:15,590
actually start to see some features from

709
00:33:19,099 --> 00:33:17,190
cloud particles

710
00:33:20,359 --> 00:33:19,109
so the spectroscopy in general is just

711
00:33:21,759 --> 00:33:20,369
fantastic for better understanding

712
00:33:23,869 --> 00:33:21,769
what's going on with an atmosphere

713
00:33:24,919 --> 00:33:23,879

especially at some of the longer

714
00:33:28,820 --> 00:33:24,929
wavelengths that we're gonna get from a

715
00:33:30,799 --> 00:33:28,830
space mission hrs stands for high

716
00:33:32,389 --> 00:33:30,809
resolution spectroscopy and if you've

717
00:33:33,950 --> 00:33:32,399
looked at the program you know that

718
00:33:36,259 --> 00:33:33,960
Jane's going to give us a whole talk

719
00:33:39,739 --> 00:33:36,269
about this and so I have refrained

720
00:33:41,210 --> 00:33:39,749
myself from calling out how wonderful

721
00:33:44,089 --> 00:33:41,220
this is going to be to understand

722
00:33:45,769 --> 00:33:44,099
atmospheres in better detail but this is

723
00:33:47,839 --> 00:33:45,779
one of my favorite things going on

724
00:33:50,089 --> 00:33:47,849
observational E right now gets your

725
00:33:52,489 --> 00:33:50,099
exquisite information it's spectroscopy

726
00:33:56,330 --> 00:33:52,499
as it's in the name and it also is

727
00:33:58,190 --> 00:33:56,340
letting you probe very detailed

728
00:34:00,379 --> 00:33:58,200
information about the atmosphere and

729
00:34:03,979 --> 00:34:00,389
including sometimes something about the

730
00:34:06,680 --> 00:34:03,989
atmospheric dynamics so as I said one of

731
00:34:10,490 --> 00:34:06,690
my favorite observational methods right

732
00:34:14,089 --> 00:34:10,500
now but I'll just call out two more

733
00:34:18,260 --> 00:34:14,099
things one is variability right so a

734
00:34:20,599 --> 00:34:18,270
standard assumption part of the vanilla

735
00:34:25,039 --> 00:34:20,609
picture of hot Jupiters is that it's a

736
00:34:27,669 --> 00:34:25,049
relatively steady state right you have

737
00:34:32,210 --> 00:34:27,679
these very strong spatially symmetries

738
00:34:35,210 --> 00:34:32,220

but when we run our knife standard GCM

739
00:34:39,950 --> 00:34:35,220
they don't change that much right and

740
00:34:41,629 --> 00:34:39,960
that's convenient in many ways but some

741
00:34:44,089 --> 00:34:41,639
of these other effects that we need to

742
00:34:45,769 --> 00:34:44,099
worry about could potentially induce

743
00:34:49,659 --> 00:34:45,779
some variability right we just saw that

744
00:34:53,809 --> 00:34:49,669
example from clouds with feedback on the

745
00:34:56,599 --> 00:34:53,819
temperature structure the horribly gross

746
00:35:00,829 --> 00:34:56,609
magnetic effects can also perhaps and do

747
00:35:04,269 --> 00:35:00,839
some variability so there here's a

748
00:35:08,329 --> 00:35:04,279
couple recent observational papers

749
00:35:10,880 --> 00:35:08,339
trying to constrain or detect possible

750
00:35:13,819 --> 00:35:10,890
variability and Hunter parameters and if

751
00:35:15,529 --> 00:35:13,829
they are variable or not that's

752
00:35:18,680 --> 00:35:15,539
informative and if we can characterize

753
00:35:20,990 --> 00:35:18,690
how much or not they are variable that

754
00:35:22,730 --> 00:35:21,000
can help limit some of our models trying

755
00:35:27,160 --> 00:35:22,740
to understand the physical processes at

756
00:35:29,660 --> 00:35:27,170
work and then because it's my other

757
00:35:31,090 --> 00:35:29,670
favorite observational technique and I

758
00:35:33,850 --> 00:35:31,100
don't think I can give a talk at X

759
00:35:38,170 --> 00:35:33,860
without talking about it I love Eclipse

760
00:35:40,390 --> 00:35:38,180
mapping so this is a technique where as

761
00:35:42,570 --> 00:35:40,400
the planet goes behind the star you

762
00:35:47,170 --> 00:35:42,580
measure the shape as the secondary

763
00:35:50,020 --> 00:35:47,180

Eclipse very carefully and these changes

764
00:35:51,850 --> 00:35:50,030
in flux are related to the brightness of

765
00:35:54,220 --> 00:35:51,860
a slice that you just covered or

766
00:35:57,250 --> 00:35:54,230
uncovered and so you can use it to make

767
00:35:57,790 --> 00:35:57,260
a 2d picture of the planet and that's

768
00:35:59,200 --> 00:35:57,800
cool

769
00:36:00,970 --> 00:35:59,210
right so from phase occurs we get

770
00:36:03,940 --> 00:36:00,980
information longitudinally around the

771
00:36:06,190 --> 00:36:03,950
planet so with eclipse masses we get to

772
00:36:09,220 --> 00:36:06,200
the information latitude and longitude

773
00:36:11,530 --> 00:36:09,230
on the day side and I think it's been

774
00:36:14,140 --> 00:36:11,540
especially exciting time for Clips math

775
00:36:17,200 --> 00:36:14,150
name because when JWST launches and

776
00:36:19,300 --> 00:36:17,210
people do a bunch of secondary eclipsed

777
00:36:22,570 --> 00:36:19,310
spectral observations of a bunch of

778
00:36:23,980 --> 00:36:22,580
bryce targets many of those data we

779
00:36:27,310 --> 00:36:23,990
think should be good enough to actually

780
00:36:28,780 --> 00:36:27,320
make math and most people who are doing

781
00:36:31,240 --> 00:36:28,790
these Jeannot these two observations are

782
00:36:33,310 --> 00:36:31,250
going to be doing them spectrally right

783
00:36:37,230 --> 00:36:33,320
and so that gives us the opportunity to

784
00:36:39,730 --> 00:36:37,240
make multi-wavelength or

785
00:36:40,840 --> 00:36:39,740
three-dimensional maps because they see

786
00:36:44,160 --> 00:36:40,850
different depths at different

787
00:36:49,330 --> 00:36:44,170
wavelengths well just gets me so excited

788
00:36:51,220 --> 00:36:49,340

so there's a group of us and I say us in

789
00:36:53,890 --> 00:36:51,230
the loosest sense I'm just along for the

790
00:36:58,000 --> 00:36:53,900
ride who are trying to develop this

791
00:37:01,330 --> 00:36:58,010
technique that combines some spatial

792
00:37:05,230 --> 00:37:01,340
mapping optimization with spectral

793
00:37:07,420 --> 00:37:05,240
information as well so you know come

794
00:37:09,580 --> 00:37:07,430
talk to any of the names on this slide

795
00:37:12,190 --> 00:37:09,590
if you want more detailed information

796
00:37:15,070 --> 00:37:12,200
but this is an example of this technique

797
00:37:16,900 --> 00:37:15,080
where you input this cartoon map with

798
00:37:18,520 --> 00:37:16,910
this very artificial hemispheric

799
00:37:21,490 --> 00:37:18,530
difference and different spectra in

800
00:37:25,960 --> 00:37:21,500
those hemispheres and this is the output

801
00:37:30,090 --> 00:37:25,970
so you group into a brighter region and

802
00:37:32,290 --> 00:37:30,100
a dimmer region and you also have cetera

803
00:37:35,620 --> 00:37:32,300
associated with each of these regions

804
00:37:39,550 --> 00:37:35,630
which look pretty good compared to the

805
00:37:43,000 --> 00:37:39,560
original input so super exciting stay

806
00:37:44,420 --> 00:37:43,010
tuned and with that I think I'm about

807
00:37:47,809 --> 00:37:44,430
out of time

808
00:37:50,059 --> 00:37:47,819
so this is it this is my take Waypoint

809
00:37:51,260 --> 00:37:50,069
when you're thinking about hot jupiter

810
00:37:55,130 --> 00:37:51,270
atmospheres they're inherently

811
00:37:57,710 --> 00:37:55,140
three-dimensional and the dynamics the

812
00:38:00,920 --> 00:37:57,720
chemistry and the clouds or Hayes's are

813
00:38:04,130 --> 00:38:00,930

all interrelated in a way that we can't

814
00:38:05,539 --> 00:38:04,140
really ignore without missing something

815
00:38:10,880 --> 00:38:05,549
potentially first-order about what's

816
00:38:10,890 --> 00:38:17,470
[Music]

817
00:38:20,870 --> 00:38:20,150
thank you so much Emily that was

818
00:38:26,810 --> 00:38:20,880
fantastic

819
00:38:28,400 --> 00:38:26,820
I got my eye at the end I'm happy so

820
00:38:31,040 --> 00:38:28,410
we're gonna take with some time for

821
00:38:32,630 --> 00:38:31,050
questions and I want to so we want

822
00:38:35,390 --> 00:38:32,640
questions from everybody don't hesitate

823
00:38:39,200 --> 00:38:35,400
to raise your hand and don't forget to

824
00:38:47,950 --> 00:38:39,210
state your name affiliation before you

825
00:38:51,980 --> 00:38:50,600
turn hearings and Andrews thank you so

826
00:38:55,130 --> 00:38:51,990
much for this entertaining talk was very

827
00:38:57,890 --> 00:38:55,140
enjoyable first of all I would like to

828
00:38:59,180 --> 00:38:57,900
follow your your call for advertising

829
00:39:00,560 --> 00:38:59,190
young people's work so there's a

830
00:39:02,420 --> 00:39:00,570
beautiful poster by do--make somewhere

831
00:39:04,160 --> 00:39:02,430
or Darren head p7v which fitted with the

832
00:39:06,020 --> 00:39:04,170
whole group of young people so I have a

833
00:39:07,670 --> 00:39:06,030
look and there's beautiful detail

834
00:39:10,550 --> 00:39:07,680
confirmation modeling on this poster

835
00:39:12,800 --> 00:39:10,560
second point I actually want to make you

836
00:39:15,290 --> 00:39:12,810
say that clouds are determined by the

837
00:39:18,080 --> 00:39:15,300
dynamics of the atmosphere I would like

838
00:39:18,920 --> 00:39:18,090

to go a little bit deeper and say thanks

839
00:39:21,440 --> 00:39:18,930
they are determined by the

840
00:39:23,300 --> 00:39:21,450
thermodynamics why does not dehydrate

841
00:39:25,370 --> 00:39:23,310
Amex the hydrodynamics sets the stage

842
00:39:27,200 --> 00:39:25,380
basically what what determines the cloud

843
00:39:29,570 --> 00:39:27,210
formation itself is the local

844
00:39:39,080 --> 00:39:29,580
thermodynamic conditions which are then

845
00:39:43,870 --> 00:39:39,090
determined by your enemies agree to do

846
00:39:48,230 --> 00:39:47,300
Nick Cowen McGill University so I have a

847
00:39:52,670 --> 00:39:48,240
comment and a question

848
00:39:57,020 --> 00:39:52,680
my comment is that weird face curve of

849
00:39:59,540 --> 00:39:57,030
wasps 12 was not my fault so my my my

850
00:40:02,180 --> 00:39:59,550
student Taylor Behl just put a paper on

851
00:40:04,400 --> 00:40:02,190
archive and that is real yeah like

852
00:40:06,530 --> 00:40:04,410
it seen it seen independently at

853
00:40:09,050 --> 00:40:06,540
different epochs by like four different

854
00:40:10,190 --> 00:40:09,060
groups who've tried analyzing it so it's

855
00:40:12,020 --> 00:40:10,200
real and we think it's actually gas

856
00:40:14,840 --> 00:40:12,030
falling like the plant is getting eaten

857
00:40:17,120 --> 00:40:14,850
by the star but guys my question is

858
00:40:19,430 --> 00:40:17,130
about the roaming and Russia paper or

859
00:40:21,020 --> 00:40:19,440
the lines paper has anyone so those were

860
00:40:24,140 --> 00:40:21,030
people trying to be self-consistent

861
00:40:26,840 --> 00:40:24,150
those are theorists pretending that that

862
00:40:28,100 --> 00:40:26,850
like they understand physics I have to

863
00:40:31,550 --> 00:40:28,110

have any Buddhist

864
00:40:34,010 --> 00:40:31,560
fun tried to look at the Demery albedo

865
00:40:36,200 --> 00:40:34,020
map of kepler 7b which wasn't

866
00:40:38,300 --> 00:40:36,210
conveniently was in community was not

867
00:40:40,610 --> 00:40:38,310
actually made into an albedo map ism

868
00:40:42,050 --> 00:40:40,620
sort of like flux map or something but

869
00:40:43,610 --> 00:40:42,060
in a review article i once converted

870
00:40:45,200 --> 00:40:43,620
into an albedo map for fun and I was

871
00:40:48,230 --> 00:40:45,210
like oh this is crazy like the Western

872
00:40:49,370 --> 00:40:48,240
Hemisphere is like 60% albedo and the

873
00:40:51,860 --> 00:40:49,380
eastern hemisphere is consistent with

874
00:40:54,110 --> 00:40:51,870
zero so has have any theorist tried

875
00:40:56,060 --> 00:40:54,120
plugging that into GCM and see whether

876
00:40:57,740 --> 00:40:56,070
you can actually maintain eastward flows

877
00:40:59,270 --> 00:40:57,750
under those circumstances because like

878
00:41:02,120 --> 00:40:59,280
naively I would think you might start

879
00:41:04,160 --> 00:41:02,130
getting like it would just screw up your

880
00:41:06,620 --> 00:41:04,170
dynamics altogether right if you have

881
00:41:08,450 --> 00:41:06,630
one side of planets is extremely

882
00:41:10,070 --> 00:41:08,460
reflective and the other that absorbs no

883
00:41:12,860 --> 00:41:10,080
problem and it's extremely reflective

884
00:41:15,830 --> 00:41:12,870
like 70 percent reflection yeah so in

885
00:41:19,190 --> 00:41:15,840
Roman and rauch or 2017 we did that

886
00:41:21,140 --> 00:41:19,200
exact test and Michael combat actually

887
00:41:25,910 --> 00:41:21,150
still maintained so standardise for

888
00:41:34,400 --> 00:41:25,920

circulation yeah yeah thanks for setting

889
00:41:36,980 --> 00:41:34,410
that one up hi Tommy let me get from

890
00:41:38,720 --> 00:41:36,990
lightning so I I had a question I I know

891
00:41:41,480 --> 00:41:38,730
that I have a biased view Taurus on

892
00:41:45,080 --> 00:41:41,490
solar system planets at least on this

893
00:41:47,150 --> 00:41:45,090
but I want to know how important are the

894
00:41:49,400 --> 00:41:47,160
lower boundary conditions like I never

895
00:41:51,170 --> 00:41:49,410
know how deep you go in your modelling

896
00:41:55,790 --> 00:41:51,180
when you are doing these 3d and how

897
00:41:58,400 --> 00:41:55,800
important it is to go even deeper I love

898
00:41:59,780 --> 00:41:58,410
it because it's a question that I can

899
00:42:00,530 --> 00:41:59,790
geek out about that most people don't

900
00:42:02,900 --> 00:42:00,540
care so much about

901
00:42:03,800 --> 00:42:02,910
although okay I like three different

902
00:42:06,320 --> 00:42:03,810
things to say and they're all fighting

903
00:42:08,690 --> 00:42:06,330
to get on my mouth so first of all we

904
00:42:13,550 --> 00:42:08,700
generally put bottom boundaries like a

905
00:42:16,010 --> 00:42:13,560
hundred bar and this is important to

906
00:42:19,370 --> 00:42:16,020
make sure that it's deep enough because

907
00:42:21,020 --> 00:42:19,380
the atmosphere that's being actively

908
00:42:23,060 --> 00:42:21,030
heated where the circulation is all

909
00:42:25,370 --> 00:42:23,070
happening needs to have momentum

910
00:42:29,030 --> 00:42:25,380
exchange with the deeper kind of inert

911
00:42:30,950 --> 00:42:29,040
layers if you put the boundary too

912
00:42:32,750 --> 00:42:30,960
shallow then you're constraining all

913
00:42:34,100 --> 00:42:32,760

your own killer momentum exchange to be

914
00:42:35,510 --> 00:42:34,110
within the spin layer and then you can

915
00:42:40,700 --> 00:42:35,520
trigger instabilities that don't

916
00:42:42,950 --> 00:42:40,710
actually we think exists it's also put

917
00:42:45,020 --> 00:42:42,960
but then the choice for how deep to put

918
00:42:47,660 --> 00:42:45,030
it is also informed by many of us

919
00:42:49,220 --> 00:42:47,670
wanting it to be above the radius of

920
00:42:53,020 --> 00:42:49,230
convective boundary so that we're still

921
00:42:55,220 --> 00:42:53,030
in a stable stratified them turns out

922
00:42:59,570 --> 00:42:55,230
there's been this series of wonderful

923
00:43:03,650 --> 00:42:59,580
papers recently including one by forums

924
00:43:05,300 --> 00:43:03,660
at all that's pointing out that many we

925
00:43:08,750 --> 00:43:05,310
know which I didn't talk about many hot

926
00:43:10,370 --> 00:43:08,760
Jupiters are inflated right larger than

927
00:43:14,020 --> 00:43:10,380
we think they should be some extra heat

928
00:43:17,450 --> 00:43:14,030
source and in tier this implies a hotter

929
00:43:21,100 --> 00:43:17,460
interior then compared to Jupiter for

930
00:43:23,720 --> 00:43:21,110
example and so your ad about actually

931
00:43:27,020 --> 00:43:23,730
it's misrepresented if you're using a

932
00:43:29,360 --> 00:43:27,030
Jupiter asked ad about and so maybe your

933
00:43:32,660 --> 00:43:29,370
radius perspective boundary is actually

934
00:43:35,780 --> 00:43:32,670
at much lower pressure then as part of

935
00:43:36,940 --> 00:43:35,790
this image people have had in their mind

936
00:43:39,920 --> 00:43:36,950
for a long time

937
00:43:52,490 --> 00:43:39,930
and that may do that has many many

938
00:43:54,680 --> 00:43:52,500

interesting consequences Felix turn

939
00:43:57,440 --> 00:43:54,690
through Martinez da parents night light

940
00:43:59,270 --> 00:43:57,450
so with the eclipse mapping you're

941
00:44:01,430 --> 00:43:59,280
looking out do you have any plans to

942
00:44:04,520 --> 00:44:01,440
look at the bottom coffin effect and

943
00:44:05,840 --> 00:44:04,530
maybe try and analyze the winds and see

944
00:44:08,030 --> 00:44:05,850
if you can get measurement if you've got

945
00:44:10,070 --> 00:44:08,040
the spectral data you should be able to

946
00:44:21,680 --> 00:44:10,080
look there so I think that's a poster

947
00:44:27,740 --> 00:44:21,690
about that Nick yeah Melissa Marquez

948
00:44:30,230 --> 00:44:27,750
poster thank you sorry absol Daniel

949
00:44:32,720 --> 00:44:30,240
called from MIT very nave question but

950
00:44:36,560 --> 00:44:32,730
how many Eclipse Maps do we actually

951
00:44:38,990 --> 00:44:36,570
have why don't we have more ultra hot

952
00:44:40,730 --> 00:44:39,000
Jupiters should be probably a very good

953
00:44:43,700 --> 00:44:40,740
target for this but would we learn

954
00:44:50,750 --> 00:44:43,710
anything by doing eclipse mapping from

955
00:44:52,910 --> 00:44:50,760
them one there's one planet that to my

956
00:44:54,410 --> 00:44:52,920
knowledge has eCos Matthew quality data

957
00:44:57,259 --> 00:44:54,420
and that's HD one a nine

958
00:44:58,430 --> 00:44:57,269
three beam which when non scientists

959
00:44:59,900 --> 00:44:58,440
think they're being funny and ask me

960
00:45:04,190 --> 00:44:59,910
what my favorite planet is that's my

961
00:45:06,440 --> 00:45:04,200
favorite planet and it's a bunch of

962
00:45:10,519 --> 00:45:06,450
stashed together eight microns Spitzer

963
00:45:12,740 --> 00:45:10,529

data so that's part of the reason that

964
00:45:15,099 --> 00:45:12,750
we don't have any other mass is there

965
00:45:19,670 --> 00:45:15,109
are no more eight micron Spitzer data

966
00:45:22,130 --> 00:45:19,680
and you need to have precise

967
00:45:24,319 --> 00:45:22,140
measurements in a short enough exposure

968
00:45:28,549 --> 00:45:24,329
that you can trace out the ingress

969
00:45:30,289 --> 00:45:28,559
small enough ultra hot Jupiters

970
00:45:33,170 --> 00:45:30,299
I agree would be really interesting to

971
00:45:34,819 --> 00:45:33,180
do some signals lights estimates see if

972
00:45:39,980 --> 00:45:34,829
that's going to produce something

973
00:45:43,849 --> 00:45:39,990
interesting and I think yes it would be

974
00:45:44,870 --> 00:45:43,859
really informative because as I pointed

975
00:45:47,029 --> 00:45:44,880
out if you can do it

976
00:45:49,549 --> 00:45:47,039
spectrally then you're not just getting

977
00:45:51,769 --> 00:45:49,559
kind of a massive thermal emission which

978
00:45:53,480 --> 00:45:51,779
in itself is cool but maybe in the

979
00:45:54,710 --> 00:45:53,490
standard eastward picture is not that

980
00:45:57,079 --> 00:45:54,720
different from the information you get

981
00:45:59,690 --> 00:45:57,089
some face curves you see any store shift

982
00:46:02,230 --> 00:45:59,700
but if you can do this spectrally as

983
00:46:04,940 --> 00:46:02,240
well then you would learn things about

984
00:46:08,390 --> 00:46:04,950
four hot Jupiters right maybe you learn

985
00:46:10,430 --> 00:46:08,400
something about weather molecules coming

986
00:46:11,870 --> 00:46:10,440
from the night side can exist on the day

987
00:46:13,309 --> 00:46:11,880
side for a while before they're

988
00:46:16,160 --> 00:46:13,319

dissociated because you would see

989
00:46:18,650 --> 00:46:16,170
spectral features associated with

990
00:46:21,829 --> 00:46:18,660
different spatial locations on the

991
00:46:24,529 --> 00:46:21,839
planet first things like clouds right it

992
00:46:26,630 --> 00:46:24,539
would be really nice to know if in a map

993
00:46:30,319 --> 00:46:26,640
with a bright region in a dim region is

994
00:46:32,450 --> 00:46:30,329
the dim region look like a spectrum of a

995
00:46:34,730 --> 00:46:32,460
cool location or does it look like a

996
00:46:43,230 --> 00:46:34,740
spectrum of a cloudy location because

997
00:46:50,860 --> 00:46:47,070
denna sir gave from University of Ecsta

998
00:46:54,700 --> 00:46:50,870
is stellar variability included in this

999
00:46:57,270 --> 00:46:54,710
model and such things as you know solar

1000
00:47:04,480 --> 00:46:57,280
flares important for this models and

1001
00:47:08,620 --> 00:47:04,490
have them in any studies I try to ignore

1002
00:47:12,670 --> 00:47:08,630
the star as they sing other than an flux

1003
00:47:15,250 --> 00:47:12,680
input into the model yes the star is

1004
00:47:16,660 --> 00:47:15,260
supremely important in all the ways so

1005
00:47:18,400 --> 00:47:16,670
it's important both in terms of

1006
00:47:20,190 --> 00:47:18,410
interpreting the observations you want

1007
00:47:22,000 --> 00:47:20,200
to make sure that the variability

1008
00:47:23,230 --> 00:47:22,010
spatial or temporal that you're

1009
00:47:27,270 --> 00:47:23,240
measuring for the planet is from the

1010
00:47:29,500 --> 00:47:27,280
planet as an input into the models

1011
00:47:33,900 --> 00:47:29,510
depends on what type of model you're

1012
00:47:37,000 --> 00:47:33,910
thinking about it's very important for

1013
00:47:38,950 --> 00:47:37,010

modeling the upper atmosphere which I

1014
00:47:40,150 --> 00:47:38,960
haven't been talking about as much here

1015
00:47:41,590 --> 00:47:40,160
I'm talking about deeper pressure lines

1016
00:47:44,170 --> 00:47:41,600
but up in the atmosphere where you're

1017
00:47:47,890 --> 00:47:44,180
having evaporation where you're

1018
00:47:49,600 --> 00:47:47,900
absorbing your UV flux more strongly it

1019
00:47:54,070 --> 00:47:49,610
can have very important consequences up

1020
00:48:00,910 --> 00:47:54,080
there just a short enough here

1021
00:48:03,070 --> 00:48:00,920
oh my gosh kick-off symmetry so I'm

1022
00:48:04,450 --> 00:48:03,080
talking about my everything I would like

1023
00:48:05,860 --> 00:48:04,460
to make a comment about what you

1024
00:48:09,040 --> 00:48:05,870
commanded oh how do you beat the

1025
00:48:11,020 --> 00:48:09,050
variability so I hope to put a number on

1026
00:48:14,170 --> 00:48:11,030
doors are not such a different type of

1027
00:48:16,000 --> 00:48:14,180
hope yes different but not that much in

1028
00:48:18,910 --> 00:48:16,010
run doors we have found so far by

1029
00:48:21,760 --> 00:48:18,920
ability after Sun stand in all of them

1030
00:48:23,440 --> 00:48:21,770
basically so I just wanted to read you

1031
00:48:25,840 --> 00:48:23,450
know that we anticipate also that hot

1032
00:48:30,610 --> 00:48:25,850
Jupiters are most rarely oh so variable

1033
00:48:32,260 --> 00:48:30,620
so yeah I I love brown dwarfs lamps I

1034
00:48:34,780 --> 00:48:32,270
think it's fantastic and I think the

1035
00:48:38,170 --> 00:48:34,790
variability from brown dwarfs is amazing

1036
00:48:41,610 --> 00:48:38,180
the there are certainly important

1037
00:48:44,950 --> 00:48:41,620
atmospheric similarities a difference is

1038
00:48:49,030 --> 00:48:44,960

the spatial pattern that we expect for

1039
00:48:52,090 --> 00:48:49,040
an homogeneity so the brown dwarfs right

1040
00:48:53,380 --> 00:48:52,100
are maybe having kind of more bands more

1041
00:48:56,230 --> 00:48:53,390
spots and

1042
00:48:58,300 --> 00:48:56,240
different spatial distribution of why

1043
00:49:00,340 --> 00:48:58,310
they're variable then we might expect

1044
00:49:02,200 --> 00:49:00,350
for the hot Jupiters so I expect that we

1045
00:49:04,240 --> 00:49:02,210
will see different types of variability

1046
00:49:11,800 --> 00:49:04,250
if we do start to see more variability

1047
00:49:13,990 --> 00:49:11,810
on hot Roberto Harrington from the

1048
00:49:15,970 --> 00:49:14,000
University of Central Florida just sort

1049
00:49:19,750 --> 00:49:15,980
of a step back question how far are we

1050
00:49:24,180 --> 00:49:19,760
today from a model that has dynamics

1051
00:49:28,600 --> 00:49:24,190
active chemistry radiation and clouds

1052
00:49:31,300 --> 00:49:28,610
including the latent heat from chemical

1053
00:49:33,430 --> 00:49:31,310
reactions because we know that in our

1054
00:49:36,610 --> 00:49:33,440
atmosphere the latent heat from

1055
00:49:38,440 --> 00:49:36,620
condensation is a major in fact yeah I

1056
00:50:15,520 --> 00:49:38,450
don't have one in the works does anybody

1057
00:50:17,830 --> 00:50:15,530
in the room hi Malik University of

1058
00:50:19,870 --> 00:50:17,840
Maryland I have a related question

1059
00:50:21,310 --> 00:50:19,880
actually so I'm working on radiative

1060
00:50:23,260 --> 00:50:21,320
transfer myself and you didn't really

1061
00:50:24,760 --> 00:50:23,270
mention the occult you treat the

1062
00:50:26,470 --> 00:50:24,770
radiative transfer in the dynamics

1063
00:50:28,180 --> 00:50:26,480

models and I know that is a very

1064
00:50:31,600 --> 00:50:28,190
difficult issue also computationally

1065
00:50:34,330 --> 00:50:31,610
wise so I guess do you think there is

1066
00:50:36,190 --> 00:50:34,340
still a lot of work to be done in terms

1067
00:50:38,380 --> 00:50:36,200
of increasing the accuracy of ready to

1068
00:50:40,390 --> 00:50:38,390
transfer treatment and also what would

1069
00:50:42,730 --> 00:50:40,400
be the impact I mean it's all coupled

1070
00:50:43,750 --> 00:50:42,740
right so you will have the different

1071
00:50:45,430 --> 00:50:43,760
heating you will have different

1072
00:50:47,350 --> 00:50:45,440
temperatures different condensation

1073
00:50:48,880 --> 00:50:47,360
points and so on which means the clouds

1074
00:50:51,640 --> 00:50:48,890
are ships that maybe they don't they

1075
00:50:55,330 --> 00:50:51,650
don't form at all so can you come in a

1076
00:50:58,090 --> 00:50:55,340
little bit more than that yeah as you

1077
00:50:59,620 --> 00:50:58,100
say the radiative transfer is very

1078
00:51:01,480 --> 00:50:59,630
important right that's how you're

1079
00:51:04,930 --> 00:51:01,490
driving the dynamics in the first place

1080
00:51:06,620 --> 00:51:04,940
and also how you're observing the planet

1081
00:51:08,779 --> 00:51:06,630
so it's very important

1082
00:51:14,109 --> 00:51:08,789
I think that of course there's room for

1083
00:51:20,180 --> 00:51:16,370
it's important to think about the level

1084
00:51:22,759 --> 00:51:20,190
of complexity that one is modelling at

1085
00:51:25,370 --> 00:51:22,769
and the physics that you're going after

1086
00:51:27,380 --> 00:51:25,380
right so I think when you're doing these

1087
00:51:29,120 --> 00:51:27,390
wonderfully complicated GCMs with all

1088
00:51:30,289 --> 00:51:29,130

the chemistry and all the clouds you

1089
00:51:33,200 --> 00:51:30,299
really need to make sure you're getting

1090
00:51:35,509 --> 00:51:33,210
the array of transfer correct at the

1091
00:51:36,769 --> 00:51:35,519
appropriate level of complexity for

1092
00:51:39,640 --> 00:51:36,779
everything else that's going on right

1093
00:51:42,859 --> 00:51:39,650
each of these pieces should basically be

1094
00:51:44,870 --> 00:51:42,869
of comparable complexity because if

1095
00:51:48,140 --> 00:51:44,880
you're doing this wonderfully beautiful

1096
00:51:51,759 --> 00:51:48,150
detailed cloud micro physics but doing

1097
00:51:53,839 --> 00:51:51,769
some slapdash simple radio transfers and

1098
00:51:57,910 --> 00:51:53,849
I don't know how that works together

1099
00:52:00,319 --> 00:51:57,920
right but I do also think that it's

1100
00:52:02,150 --> 00:52:00,329
valuable to have models at a bunch of

1101
00:52:04,099 --> 00:52:02,160
different levels of complexity so you

1102
00:52:06,890 --> 00:52:04,109
can see how these pieces work together