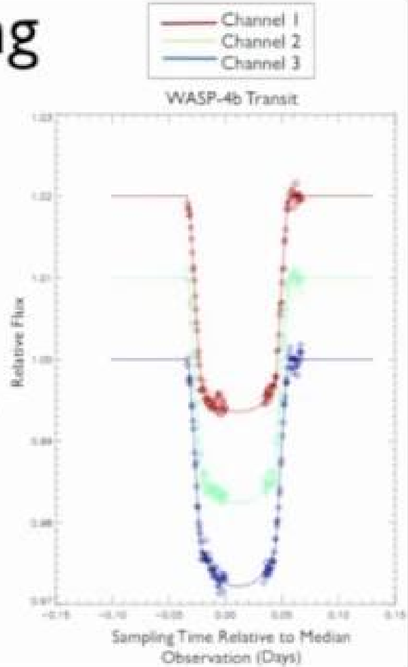
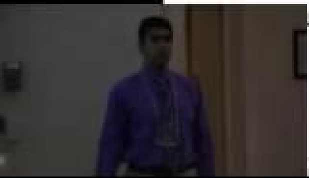
Fitting

- Fit analytic lightcurve model for each channel (Mandel & Agol 2002)
  - Free parameter: depth
  - Epoch: white-light curve. Other parameters: literature
  - 4-parameter limb-darkening laws from ATLAS stellar models (Kurucz & Castelli 2003)
- Parameter errors: MCMC, ual Permutations





1
00:00:09,830 --> 00:00:07,670
second talk of the day so creech who

2
00:00:12,650 --> 00:00:09,840
will be talking about some hot Jupiter

3
00:00:14,720 --> 00:00:12,660
atmospheres all right everyone thank you

4
00:00:15,740 --> 00:00:14,730
for having me here to talk to you my

5
00:00:17,540 --> 00:00:15,750
name is sue Kurt and I'm going to

6
00:00:19,190 --> 00:00:17,550
discuss with you a project I've been

7
00:00:21,140 --> 00:00:19,200
leading over the last few years to study

8
00:00:23,330 --> 00:00:21,150
the atmospheres of five hot Jupiter

9
00:00:27,529 --> 00:00:23,340
exoplanets using the Hubble Space

10
00:00:31,250 --> 00:00:27,539
Telescope so hmm how do I make this go

11
00:00:32,509 --> 00:00:31,260
ah like that wonderful so just as an

12
00:00:33,890 --> 00:00:32,519
outline of my talk I'm going to start

13
00:00:35,329 --> 00:00:33,900

off by first giving a little bit of an

14
00:00:37,490 --> 00:00:35,339
overview of the field of transit

15
00:00:38,810 --> 00:00:37,500
spectroscopy what it is and why we care

16
00:00:41,030 --> 00:00:38,820
about it since I know this is a meeting

17
00:00:42,799 --> 00:00:41,040
for a very multidisciplinary meeting

18
00:00:44,479 --> 00:00:42,809
from there I'll move on to what

19
00:00:47,270 --> 00:00:44,489
specifically we were trying to do with

20
00:00:49,250 --> 00:00:47,280
our project I'll move on to the data we

21
00:00:50,510 --> 00:00:49,260
collected and how we analyzed it what we

22
00:00:53,840 --> 00:00:50,520
found and then I'll wrap up and

23
00:00:55,880 --> 00:00:53,850
summarize okay so just as a quick

24
00:00:57,619 --> 00:00:55,890
overview the last few years have really

25
00:00:59,240 --> 00:00:57,629
been a golden age for exoplanets our

26
00:01:01,340 --> 00:00:59,250
discovery rate has been increasing at an

27
00:01:03,439 --> 00:01:01,350
exponential rate particularly these last

28
00:01:05,749 --> 00:01:03,449
few years we have almost a thousand

29
00:01:07,609 --> 00:01:05,759
confirmed exoplanets today and about

30
00:01:09,020 --> 00:01:07,619
3,000 work candidates to go ahead and

31
00:01:11,270 --> 00:01:09,030
validate and vet so that's really

32
00:01:13,010 --> 00:01:11,280
awesome the problem is for most of these

33
00:01:14,630 --> 00:01:13,020
objects we only have radius or mass

34
00:01:16,609 --> 00:01:14,640
estimates so we know nothing beyond

35
00:01:18,260 --> 00:01:16,619
vaguely how big they are and that's a

36
00:01:19,130 --> 00:01:18,270
problem from an astrobiology perspective

37
00:01:21,020 --> 00:01:19,140
because if we're trying to characterize

38
00:01:22,940 --> 00:01:21,030

their habitability or look for evidence

39
00:01:25,880 --> 00:01:22,950
of life we really need to know a lot

40
00:01:27,169 --> 00:01:25,890
more but these observations it's very

41
00:01:28,520 --> 00:01:27,179
hard to do that kind of observations

42
00:01:30,350 --> 00:01:28,530
first because the planet is a dim

43
00:01:31,850 --> 00:01:30,360
relative to its star and second because

44
00:01:33,350 --> 00:01:31,860
it's really hard to separate them out so

45
00:01:36,710 --> 00:01:33,360
it's hard to differentiate the planets

46
00:01:37,910 --> 00:01:36,720
emission from the stars emission so for

47
00:01:40,520 --> 00:01:37,920
most of these plants are kind of stuck

48
00:01:42,139 --> 00:01:40,530
but for one particular subset of planets

49
00:01:44,270 --> 00:01:42,149
the transiting planets we can do a lot

50
00:01:45,650 --> 00:01:44,280
more so just as a reminder these are the

51
00:01:47,900 --> 00:01:45,660
planets that pass in front of their

52
00:01:49,279 --> 00:01:47,910
stars from our point of view and for

53
00:01:52,040 --> 00:01:49,289
these objects we can actually extract

54
00:01:54,440 --> 00:01:52,050
low resolution spectra so how do we do

55
00:01:55,910 --> 00:01:54,450
that well there's two phases first in

56
00:01:57,499 --> 00:01:55,920
primary eclipse or transit where the

57
00:02:00,080 --> 00:01:57,509
planet passes in front of its hosts

58
00:02:01,729 --> 00:02:00,090
hosts are thus implanted starlight

59
00:02:03,830 --> 00:02:01,739
filters through the terminator region of

60
00:02:07,100 --> 00:02:03,840
the atmosphere imprinting a very subtle

61
00:02:08,660 --> 00:02:07,110
absorption spectrum when the planet

62
00:02:09,889 --> 00:02:08,670
passes behind its star you go from

63
00:02:11,510 --> 00:02:09,899

seeing the light of the planet and the

64
00:02:13,550 --> 00:02:11,520
star to seeing just a light of the star

65
00:02:15,110 --> 00:02:13,560
so if you difference that out you see

66
00:02:17,380 --> 00:02:15,120
the dayside hemisphere integrated

67
00:02:20,149 --> 00:02:17,390
emission spectrum of the planet

68
00:02:21,589 --> 00:02:20,159
taken together this lets us understand

69
00:02:23,660 --> 00:02:21,599
parameters such as the composition of

70
00:02:25,670 --> 00:02:23,670
the atmosphere its thermal structure and

71
00:02:28,489 --> 00:02:25,680
its dynamics including the presence and

72
00:02:30,289 --> 00:02:28,499
absence of clouds as well as any

73
00:02:34,490 --> 00:02:30,299
atmospheric escape that's going on so

74
00:02:36,199 --> 00:02:34,500
that's really awesome for for these

75
00:02:37,819 --> 00:02:36,209
these measurements are still rather

76
00:02:38,990 --> 00:02:37,829
challenging so the instruments and the

77
00:02:40,399 --> 00:02:39,000
techniques we have today we've mostly

78
00:02:42,259 --> 00:02:40,409
been focusing on planets in the hot

79
00:02:44,539 --> 00:02:42,269
Jupiter class so these are gas giants

80
00:02:46,009 --> 00:02:44,549
like Jupiter that orbit an extremely

81
00:02:47,119 --> 00:02:46,019
Coast and close to their host star so

82
00:02:49,149 --> 00:02:47,129
I'm talking periods of a few days

83
00:02:52,129 --> 00:02:49,159
temperatures of thousands of Kelvin

84
00:02:53,569 --> 00:02:52,139
we're refining our oh so these objects

85
00:02:54,649 --> 00:02:53,579
are interesting in of themselves for

86
00:02:56,539 --> 00:02:54,659
their planetary science from an

87
00:02:57,920 --> 00:02:56,549
astrobiology perspective kind of the

88
00:02:59,689 --> 00:02:57,930

goal is to refine our techniques on

89
00:03:01,429 --> 00:02:59,699
these easy objects and eventually push

90
00:03:02,809 --> 00:03:01,439
down to smaller earth-like planets and

91
00:03:04,580 --> 00:03:02,819
look for bio signatures on that

92
00:03:06,890 --> 00:03:04,590
metabolic bio signatures such as oxygen

93
00:03:07,909 --> 00:03:06,900
and methane and so on and so forth so

94
00:03:08,780 --> 00:03:07,919
that's kind of the kind of the big

95
00:03:10,819 --> 00:03:08,790
picture where we're going from

96
00:03:13,250 --> 00:03:10,829
astrobiology perspective so what exactly

97
00:03:14,689 --> 00:03:13,260
were we doing well what we're really

98
00:03:17,240 --> 00:03:14,699
trying to do is bring the field of

99
00:03:19,369 --> 00:03:17,250
transit spectroscopy upon Jupiter's into

100
00:03:20,750 --> 00:03:19,379
its technological maturity and so what

101
00:03:22,670 --> 00:03:20,760
we're doing there is transitioning from

102
00:03:24,229 --> 00:03:22,680
doing one-off studies of aw objects to

103
00:03:26,929 --> 00:03:24,239
really doing a systematic comparative

104
00:03:29,020 --> 00:03:26,939
study the first one really done for a

105
00:03:31,159 --> 00:03:29,030
for hot Jupiters in the near-ir and

106
00:03:33,229 --> 00:03:31,169
towards us and we were allocated a

107
00:03:36,069 --> 00:03:33,239
hundred and fifteen orbits of Hubble

108
00:03:38,360 --> 00:03:36,079
time to study 16 different hot Jupiters

109
00:03:39,890 --> 00:03:38,370
using the new wide field camera 3

110
00:03:41,899 --> 00:03:39,900
instron and hubble that was installing

111
00:03:43,939 --> 00:03:41,909
the last servicing mission we're looking

112
00:03:47,390 --> 00:03:43,949
with the g1 41 grizzin which spans oh

113
00:03:50,030 --> 00:03:47,400

I'm just excuse me which spans 1.1 to

114
00:03:52,099 --> 00:03:50,040
1.7 microns and this has two features

115
00:03:53,599 --> 00:03:52,109
that are a huge interest to us first you

116
00:03:55,699 --> 00:03:53,609
have this kind of water absorption band

117
00:03:57,080 --> 00:03:55,709
at one point 4 microns so measurements

118
00:03:59,509 --> 00:03:57,090
there can constrain the composition of

119
00:04:01,520 --> 00:03:59,519
the planet second you have this kind of

120
00:04:03,110 --> 00:04:01,530
a window into the planets photosphere at

121
00:04:04,909 --> 00:04:03,120
one point six microns so there are no

122
00:04:06,199 --> 00:04:04,919
mature observers there and that lets us

123
00:04:08,959 --> 00:04:06,209
contained the energy budget of the

124
00:04:10,539 --> 00:04:08,969
planet so those are kind of and this

125
00:04:12,920 --> 00:04:10,549
work can only really be done from space

126
00:04:14,749 --> 00:04:12,930
this and that this figure here

127
00:04:18,050 --> 00:04:14,759
illustrates out the black curve here is

128
00:04:19,640 --> 00:04:18,060
with c3 sensitivity the red curve is

129
00:04:21,469 --> 00:04:19,650
telluric absorption so absorption from

130
00:04:23,089 --> 00:04:21,479
the Earth's atmosphere and you can see

131
00:04:24,920 --> 00:04:23,099
the very same water feature we hope to

132
00:04:27,379 --> 00:04:24,930
observe on exoplanets is also present in

133
00:04:28,969 --> 00:04:27,389
our atmosphere obfuscating observations

134
00:04:30,879 --> 00:04:28,979
so we unfortunately have to go to space

135
00:04:33,110 --> 00:04:30,889
for this kind of work

136
00:04:36,200 --> 00:04:33,120
this slide here has just meant too ill

137
00:04:37,820 --> 00:04:36,210
to introduce you to our targets so each

138
00:04:39,409 --> 00:04:37,830

of these black diamonds is a transiting

139
00:04:43,000 --> 00:04:39,419
exoplanet these are the known transiting

140
00:04:46,850 --> 00:04:43,010
hot Jupiters as of this past September

141
00:04:49,129 --> 00:04:46,860
the on the targets an hour an hour study

142
00:04:51,320 --> 00:04:49,139
are circled in either circled in blue or

143
00:04:52,640 --> 00:04:51,330
boxed in red depending on whether we

144
00:04:55,280 --> 00:04:52,650
observe them in transition or eclipse

145
00:04:57,050 --> 00:04:55,290
some we observe in both the planets that

146
00:04:59,320 --> 00:04:57,060
we specifically that I specifically I'm

147
00:05:02,659 --> 00:04:59,330
going to present to you are in green ah

148
00:05:04,879 --> 00:05:02,669
the our sample includes includes a very

149
00:05:06,350 --> 00:05:04,889
broad range of diversity it includes

150
00:05:08,870 --> 00:05:06,360
planets with and without a thermal

151
00:05:10,280 --> 00:05:08,880
inversion and we and planets that are

152
00:05:12,350 --> 00:05:10,290
bloated and planets that are non bloated

153
00:05:14,659 --> 00:05:12,360
so we have a pretty broad range of the

154
00:05:16,010 --> 00:05:14,669
hot Jupiters in our sample so the

155
00:05:18,379 --> 00:05:16,020
planets I'm going to discuss today we

156
00:05:20,090 --> 00:05:18,389
have three of them in transmission one

157
00:05:22,310 --> 00:05:20,100
of them in emission and one of them was

158
00:05:26,420 --> 00:05:22,320
four in both oh dear laser pointers

159
00:05:29,240 --> 00:05:26,430
dying how sad okay so those are objects

160
00:05:30,980 --> 00:05:29,250
what did we do to them well the what we

161
00:05:33,439 --> 00:05:30,990
basically did is we use Hubble to image

162
00:05:35,629 --> 00:05:33,449
to take a time series of spectra during

163
00:05:37,940 --> 00:05:35,639

the course of an event so as the planet

164
00:05:39,650 --> 00:05:37,950
transited or went through an eclipse we

165
00:05:41,270 --> 00:05:39,660
continually image the star and to expect

166
00:05:43,610 --> 00:05:41,280
drove it we converted these two

167
00:05:45,920 --> 00:05:43,620
dimensional spectra and 21 them into a

168
00:05:47,300 --> 00:05:45,930
one dimensional extracted spectrum we

169
00:05:49,580 --> 00:05:47,310
did background subtraction do and to

170
00:05:51,409 --> 00:05:49,590
correct out for the effects of residual

171
00:05:52,640 --> 00:05:51,419
starlight or whatever and that's all we

172
00:05:54,830 --> 00:05:52,650
did to the data so that's what you get

173
00:05:56,719 --> 00:05:54,840
with very minimal processing we've been

174
00:05:58,370 --> 00:05:56,729
down the data if so we'd agree to this

175
00:05:59,719 --> 00:05:58,380
the spectral resolution in order to

176
00:06:02,930 --> 00:05:59,729
improve the precision per wavelength

177
00:06:04,159 --> 00:06:02,940
element so that's what these vertical

178
00:06:05,659 --> 00:06:04,169
lines here are they do market the

179
00:06:07,850 --> 00:06:05,669
wavelength ins we broke down our spectra

180
00:06:09,620 --> 00:06:07,860
into so what do you get if you do that

181
00:06:11,480 --> 00:06:09,630
well you get something that looks like

182
00:06:14,810 --> 00:06:11,490
this so this is the transit light curve

183
00:06:16,250 --> 00:06:14,820
for the planet wasp for an integrated

184
00:06:18,440 --> 00:06:16,260
white light so if integrated across the

185
00:06:20,360 --> 00:06:18,450
entire band pass and so right off the

186
00:06:22,520 --> 00:06:20,370
bat you see our transit you see the dip

187
00:06:24,830 --> 00:06:22,530
in starlight due to the passage of the

188
00:06:26,270 --> 00:06:24,840

planet in front of the star and without

189
00:06:27,680 --> 00:06:26,280
any post-processing that's already

190
00:06:29,120 --> 00:06:27,690
evident so this is already a huge

191
00:06:31,250 --> 00:06:29,130
improvement from Nick MOS and other

192
00:06:33,529 --> 00:06:31,260
instruments in space so this is a very

193
00:06:35,240 --> 00:06:33,539
good sign for with c3 there's a

194
00:06:36,620 --> 00:06:35,250
systematic that's evident that's that's

195
00:06:39,050 --> 00:06:36,630
this kind of ramp effect which are

196
00:06:40,279 --> 00:06:39,060
rapidly rises and levels off but that's

197
00:06:42,020 --> 00:06:40,289
the only one and what's good about

198
00:06:43,340 --> 00:06:42,030
what's good news about that is that it's

199
00:06:44,870 --> 00:06:43,350
highly periodic

200
00:06:47,270 --> 00:06:44,880
means we can remove it without reference

201
00:06:49,130 --> 00:06:47,280
to an instrument model so we to remove

202
00:06:51,740 --> 00:06:49,140
this effect we follow the divide method

203
00:06:53,270 --> 00:06:51,750
pioneered by Berta at all the bit is

204
00:06:54,740 --> 00:06:53,280
deliberate our advisors Canadian and

205
00:06:57,320 --> 00:06:54,750
Zach when I'd have a little bit of fun

206
00:06:58,760 --> 00:06:57,330
with them and so the way that works is

207
00:07:00,740 --> 00:06:58,770
you take the two out of transit orbits

208
00:07:02,090 --> 00:07:00,750
you average them together and divide

209
00:07:04,130 --> 00:07:02,100
them into the in transit orbits and

210
00:07:07,340 --> 00:07:04,140
voila you end up with the photon noise

211
00:07:08,810 --> 00:07:07,350
limited light curve and so that's really

212
00:07:10,280 --> 00:07:08,820
great we're able to decorah late without

213
00:07:11,690 --> 00:07:10,290

reference to an instrument model we care

214
00:07:15,080 --> 00:07:11,700
about this because the predecessor to

215
00:07:16,760 --> 00:07:15,090
with c3 Nick most required an instrument

216
00:07:19,220 --> 00:07:16,770
model to D correlate systemic effects

217
00:07:20,630 --> 00:07:19,230
and that and that introduced a lot of a

218
00:07:21,980 --> 00:07:20,640
kind of discussion that people weren't

219
00:07:23,480 --> 00:07:21,990
really sure whether the features you are

220
00:07:25,010 --> 00:07:23,490
getting out of those spectra would you

221
00:07:26,120 --> 00:07:25,020
do the instrument or we're due to

222
00:07:27,770 --> 00:07:26,130
something that was actually asked you're

223
00:07:30,580 --> 00:07:27,780
physically there so we sidestepped that

224
00:07:33,740 --> 00:07:30,590
debate entirely with this with our work

225
00:07:35,480 --> 00:07:33,750
once you have those d correlated d

226
00:07:38,330 --> 00:07:35,490
correlated light curves you fit a

227
00:07:39,650 --> 00:07:38,340
transit model in each channel so you the

228
00:07:41,060 --> 00:07:39,660
only free parameter allows depth

229
00:07:42,590 --> 00:07:41,070
everything else is locked down to either

230
00:07:44,120 --> 00:07:42,600
the literature values or what you

231
00:07:45,920 --> 00:07:44,130
compute from theoretical stellar models

232
00:07:47,540 --> 00:07:45,930
and you estimate the errors in two

233
00:07:49,550 --> 00:07:47,550
different ways Markov chain Monte Carlo

234
00:07:50,780 --> 00:07:49,560
and residual permutations and you choose

235
00:07:51,980 --> 00:07:50,790
whichever gives you the larger error

236
00:07:53,630 --> 00:07:51,990
since you're looking at different

237
00:07:56,060 --> 00:07:53,640
sources of error so we're trying to be

238
00:08:00,260 --> 00:07:56,070

as conservative as we can in estimating

239
00:08:01,400 --> 00:08:00,270
a precision so what do you find well you

240
00:08:02,990 --> 00:08:01,410
find something that looks like this

241
00:08:04,760 --> 00:08:03,000
these four plots here are the

242
00:08:07,160 --> 00:08:04,770
transmission spectrum we extracted for

243
00:08:09,830 --> 00:08:07,170
the 444 of the planets in our survey so

244
00:08:12,740 --> 00:08:09,840
that's trace to trace for core 01 and

245
00:08:15,950 --> 00:08:12,750
wasp or three of these are pretty

246
00:08:18,110 --> 00:08:15,960
similar trace to trace for and Kuro one

247
00:08:20,870 --> 00:08:18,120
are all very similar essentially flat I

248
00:08:22,850 --> 00:08:20,880
present here a schematic I presenter and

249
00:08:25,370 --> 00:08:22,860
the example of trace to to kind of zoom

250
00:08:27,380 --> 00:08:25,380
in and discuss the black points are the

251
00:08:29,180 --> 00:08:27,390
transmission spectra that we derived the

252
00:08:31,850 --> 00:08:29,190
red point is just a simple flat line fit

253
00:08:34,130 --> 00:08:31,860
the blue points are conventional solar

254
00:08:37,130 --> 00:08:34,140
composition oxygen-rich atmospheric

255
00:08:39,170 --> 00:08:37,140
model and the green points are a more

256
00:08:40,850 --> 00:08:39,180
exotic carbon-rich atmospheric model

257
00:08:45,950 --> 00:08:40,860
models courtesy of nickel mother's to

258
00:08:47,390 --> 00:08:45,960
them the basic the what we basically say

259
00:08:48,890 --> 00:08:47,400
out of this is that all the models for

260
00:08:50,030 --> 00:08:48,900
the data equally well our precision is

261
00:08:53,360 --> 00:08:50,040
not high enough to differentiate between

262
00:08:55,130 --> 00:08:53,370
them however what we can do is rule out

263
00:08:56,720 --> 00:08:55,140

atmosphere creations on the scale of 10

264
00:08:58,040 --> 00:08:56,730
scale heights or more

265
00:08:59,389 --> 00:08:58,050
and this is significant because there

266
00:09:01,340 --> 00:08:59,399
have been atmospheric models published

267
00:09:03,470 --> 00:09:01,350
which called for variations of this size

268
00:09:07,550 --> 00:09:03,480
so we can at least show that such models

269
00:09:09,620 --> 00:09:07,560
are not typical the case of wasp or is a

270
00:09:11,720 --> 00:09:09,630
little more exotic and for this we

271
00:09:14,569 --> 00:09:11,730
actually do see a source of absorption I

272
00:09:16,519 --> 00:09:14,579
should clarify here that since so the

273
00:09:18,470 --> 00:09:16,529
y-axis here is the effective

274
00:09:20,329 --> 00:09:18,480
planet-sized so absorption shows up as a

275
00:09:21,110 --> 00:09:20,339
larger effective planet so in case

276
00:09:23,720 --> 00:09:21,120
you're wondering by an absorption

277
00:09:25,310 --> 00:09:23,730
feature goes up so we have an absorption

278
00:09:26,780 --> 00:09:25,320
feature at one point three microns this

279
00:09:27,829 --> 00:09:26,790
is super weird because we don't expect

280
00:09:29,360 --> 00:09:27,839
there to be absorption at one point

281
00:09:32,780 --> 00:09:29,370
three microns so we expected to see same

282
00:09:33,920 --> 00:09:32,790
thing here but we don't and so so this

283
00:09:35,689 --> 00:09:33,930
is actually fairly significant

284
00:09:37,400 --> 00:09:35,699
traditional cloud-free atmospheric

285
00:09:39,500 --> 00:09:37,410
models are ruled out at ten sigma or

286
00:09:41,660 --> 00:09:39,510
greater so this is for so there's

287
00:09:42,949 --> 00:09:41,670
something here on the first thing we did

288
00:09:44,389 --> 00:09:42,959

is we went back and put this through a

289
00:09:46,579 --> 00:09:44,399
whole battery of tests to see if you

290
00:09:48,139 --> 00:09:46,589
could explain this effect from ah from

291
00:09:50,569 --> 00:09:48,149
stellar activity or from instrumental

292
00:09:52,220 --> 00:09:50,579
effects we can't so far we want to be

293
00:09:53,480 --> 00:09:52,230
very conservative of this whole thing so

294
00:09:55,310 --> 00:09:53,490
we're not claiming the detection of a

295
00:09:56,870 --> 00:09:55,320
new feature we are saying that there is

296
00:09:59,180 --> 00:09:56,880
grounds for further follow-up studies

297
00:10:00,290 --> 00:09:59,190
including follow-up observations as well

298
00:10:04,370 --> 00:10:00,300
as reanalysis using independent

299
00:10:06,170 --> 00:10:04,380
techniques of this data set we also

300
00:10:08,150 --> 00:10:06,180
derived thermal emission spectra for two

301
00:10:10,160 --> 00:10:08,160
planets so one of those was lost for so

302
00:10:12,829 --> 00:10:10,170
we have wasp porn transmission and in

303
00:10:14,379 --> 00:10:12,839
the mission ah so this is a little bit

304
00:10:17,870 --> 00:10:14,389
of a busy diagram so I'm going to try to

305
00:10:20,240 --> 00:10:17,880
explicate it a little bit so we what we

306
00:10:21,829 --> 00:10:20,250
have or down over here is our data but

307
00:10:23,210 --> 00:10:21,839
we also have a little bit of other data

308
00:10:24,980 --> 00:10:23,220
other folks if found so this is a

309
00:10:26,949 --> 00:10:24,990
broadband point from Casares at all and

310
00:10:29,540 --> 00:10:26,959
this is from the Spitzer Space Telescope

311
00:10:31,730 --> 00:10:29,550
you have a three different model shown

312
00:10:34,490 --> 00:10:31,740
here one of them in red is an

313
00:10:36,620 --> 00:10:34,500

oxygen-rich model with an atmospheric

314
00:10:39,050 --> 00:10:36,630
inversion so that's a TP profile over

315
00:10:41,389 --> 00:10:39,060
here and you also have two non-inverted

316
00:10:44,360 --> 00:10:41,399
atmospheres one oxygen rich in blue and

317
00:10:46,340 --> 00:10:44,370
one carbon rich in green our data

318
00:10:48,590 --> 00:10:46,350
specifically is shown zoomed in here in

319
00:10:51,559 --> 00:10:48,600
this inset and the bottom line is that

320
00:10:53,600 --> 00:10:51,569
we we strongly disfavor water-rich

321
00:10:55,100 --> 00:10:53,610
models we seem to we seem to be much

322
00:10:56,990 --> 00:10:55,110
more consistent with water poor models

323
00:10:59,600 --> 00:10:57,000
and in particular non-inverted

324
00:11:00,800 --> 00:10:59,610
atmospheres and by not inverted I don't

325
00:11:02,389 --> 00:11:00,810
mean strongly non-inverted which would

326
00:11:04,750 --> 00:11:02,399
look something like that but we clean on

327
00:11:06,920 --> 00:11:04,760
adverted isothermal atmospheres and

328
00:11:09,820 --> 00:11:06,930
non-inverting as fears are ruled out

329
00:11:11,710 --> 00:11:09,830
particularly by the spitzer data so the

330
00:11:15,670 --> 00:11:11,720
kind of food data we have right now is a

331
00:11:17,880 --> 00:11:15,680
carbon-rich non-inverted model we have

332
00:11:20,620 --> 00:11:17,890
we derive similar results or trace three

333
00:11:21,820 --> 00:11:20,630
to explicate data data here our data is

334
00:11:24,850 --> 00:11:21,830
shown over here and zoomed in on this

335
00:11:26,620 --> 00:11:24,860
inset spitzer measurements are here and

336
00:11:28,030 --> 00:11:26,630
ground-based measurements are here the

337
00:11:30,610 --> 00:11:28,040
green curve is a solar composition

338
00:11:33,100 --> 00:11:30,620

atmosphere the brown curve is a depleted

339
00:11:34,990 --> 00:11:33,110
volatile atmosphere so depleted by by a

340
00:11:37,780 --> 00:11:35,000
factor of 10 relative to solar and water

341
00:11:39,100 --> 00:11:37,790
and carbon dioxide and we also show a

342
00:11:42,700 --> 00:11:39,110
black body which corresponds to an

343
00:11:44,770 --> 00:11:42,710
isothermal atmosphere and the lot of the

344
00:11:47,680 --> 00:11:44,780
upshot is between the our data and the

345
00:11:49,630 --> 00:11:47,690
Spitzer data we're able to constrain out

346
00:11:51,370 --> 00:11:49,640
the isothermal atmospheres as well as

347
00:11:52,840 --> 00:11:51,380
the solar composition atmosphere the

348
00:11:55,420 --> 00:11:52,850
best competent the best fit seems to be

349
00:11:57,310 --> 00:11:55,430
from a depleted volatile atmosphere so

350
00:11:58,960 --> 00:11:57,320
what's the upshot of all of this well

351
00:12:00,580 --> 00:11:58,970
the first in perhaps the most important

352
00:12:02,560 --> 00:12:00,590
result as this is that we demonstrate

353
00:12:04,090 --> 00:12:02,570
that with c3 is a very suitable

354
00:12:06,520 --> 00:12:04,100
instrument for these kind of broad based

355
00:12:08,290 --> 00:12:06,530
studies of exoplanet atmospheres so you

356
00:12:09,880 --> 00:12:08,300
can get strong good reliable

357
00:12:10,990 --> 00:12:09,890
transmission spectra from this and this

358
00:12:15,340 --> 00:12:11,000
instrument is great for exoplanets

359
00:12:16,900 --> 00:12:15,350
science for our target specifically we

360
00:12:19,120 --> 00:12:16,910
derive for transmission spectra and two

361
00:12:20,410 --> 00:12:19,130
emission spectra from our emission

362
00:12:22,060 --> 00:12:20,420
spectra we show that larger that

363
00:12:23,950 --> 00:12:22,070

atmospheric models with large scale

364
00:12:25,630 --> 00:12:23,960
variations are not common so things that

365
00:12:27,670 --> 00:12:25,640
happen so if you have an atmospheric

366
00:12:29,230 --> 00:12:27,680
model that has variations of more than

367
00:12:30,370 --> 00:12:29,240
10 scale heights that's probably not

368
00:12:33,240 --> 00:12:30,380
going to be very common in the hot

369
00:12:35,680 --> 00:12:33,250
Jupiter class at least if it stays free

370
00:12:37,000 --> 00:12:35,690
we identify a potential new feature in

371
00:12:38,590 --> 00:12:37,010
the wasp for atmosphere that reserves

372
00:12:40,900 --> 00:12:38,600
follow-up and bass are an emission

373
00:12:42,580 --> 00:12:40,910
spectra we find that our exoplanets are

374
00:12:46,090 --> 00:12:42,590
a little bit more water port than we

375
00:12:47,380 --> 00:12:46,100
expected them to be and if you really

376
00:12:49,120 --> 00:12:47,390
want to nail down the water composition

377
00:12:50,740 --> 00:12:49,130
we also show that since we're spectively

378
00:12:52,210 --> 00:12:50,750
photon noise limited what you really

379
00:12:54,130 --> 00:12:52,220
want is more photon so you need to do a

380
00:12:55,960 --> 00:12:54,140
multi visit observing campaign if you

381
00:12:58,540 --> 00:12:55,970
want to really try to characterize the

382
00:13:01,810 --> 00:12:58,550
abundance of water because this seems to

383
00:13:03,070 --> 00:13:01,820
be more water poor than expected so

384
00:13:04,150 --> 00:13:03,080
that's roughly where so that's roughly

385
00:13:19,869 --> 00:13:04,160
where we're at I'd love to take

386
00:13:25,100 --> 00:13:22,309
certainly so I'm not an expert on this I

387
00:13:26,720 --> 00:13:25,110
would really absolutely so the question

388
00:13:29,059 --> 00:13:26,730

was could I elaborate more on what i

389
00:13:30,800 --> 00:13:29,069
mean by carbon-rich atmospheres um so

390
00:13:32,240 --> 00:13:30,810
I'm not an expert on this the seminal

391
00:13:35,179 --> 00:13:32,250
paper certain my new COO mother's to

392
00:13:36,470 --> 00:13:35,189
them but basically so so so

393
00:13:38,749 --> 00:13:36,480
traditionally in exoplanets we always

394
00:13:39,650 --> 00:13:38,759
assume that okay a hot Jupiters

395
00:13:42,410 --> 00:13:39,660
atmosphere is probably going to be

396
00:13:43,759 --> 00:13:42,420
similar to its star and and generally

397
00:13:45,769 --> 00:13:43,769
that means you have a carbon to oxygen

398
00:13:46,699 --> 00:13:45,779
ratio that's less than one if on the

399
00:13:49,189 --> 00:13:46,709
other hand you have a carbon to oxygen

400
00:13:50,269 --> 00:13:49,199
ratio that's greater than one on the

401
00:13:51,350 --> 00:13:50,279
what all the water is going to go away

402
00:13:52,819 --> 00:13:51,360
and all you're going to be left with is

403
00:13:53,960 --> 00:13:52,829
a bunch of carbon compounds so the

404
00:13:56,480 --> 00:13:53,970
atmospheric spectrum will be really

405
00:13:58,639 --> 00:13:56,490
different a carbon-rich a rat mysterious

406
00:14:01,009 --> 00:13:58,649
claim for the exoplanet lost 12 it was

407
00:14:03,110 --> 00:14:01,019
later disfavored based on based on re

408
00:14:04,670 --> 00:14:03,120
analysis of the data however it still

409
00:14:13,730 --> 00:14:04,680
remains a valid possibility that we need

410
00:14:15,079 --> 00:14:13,740
to consider go ahead so the question was

411
00:14:16,759 --> 00:14:15,089
if we had to speculate on what the wasp

412
00:14:19,249 --> 00:14:16,769
or feature was what would he expect it

413
00:14:20,689 --> 00:14:19,259

be the answers we have no idea we spent

414
00:14:23,509 --> 00:14:20,699
literally about a year trying to follow

415
00:14:24,499 --> 00:14:23,519
up and figure out ways the to explain

416
00:14:26,300 --> 00:14:24,509
what was going wrong because we were

417
00:14:28,009 --> 00:14:26,310
pretty sure we were wrong the only

418
00:14:29,150 --> 00:14:28,019
reason I'm presenting it to you now is

419
00:14:30,439 --> 00:14:29,160
that we couldn't figure out why we were

420
00:14:32,240 --> 00:14:30,449
wrong so we have to conclude that maybe

421
00:14:33,530 --> 00:14:32,250
it's real the reason we were so

422
00:14:35,689 --> 00:14:33,540
conservative is that there exists

423
00:14:37,639 --> 00:14:35,699
nothing in conventional hot Jupiter line

424
00:14:40,519 --> 00:14:37,649
lists that absorbs there in any