
AbSciCon
2017
MESA, ARIZONA

1
00:00:12,250 --> 00:00:06,150
you

2
00:00:18,700 --> 00:00:14,310
[Music]

3
00:00:21,460 --> 00:00:18,710
hi everyone I'm chewing my thanks for

4
00:00:23,320 --> 00:00:21,470
the previous speaker give some

5
00:00:26,019 --> 00:00:23,330
introduction about the common seat in a

6
00:00:29,050 --> 00:00:26,029
transmission spectrum so today I'm going

7
00:00:32,530 --> 00:00:29,060
to talk about my work on exploring the

8
00:00:37,979 --> 00:00:32,540
cloud functions of exoplanets with JWST

9
00:00:41,680 --> 00:00:37,989
transmission spectrum with my client so

10
00:00:44,229 --> 00:00:41,690
the atmosphere of an exoplanet is the

11
00:00:46,900 --> 00:00:44,239
portion that is most readily observable

12
00:00:49,750 --> 00:00:46,910
and the characterization of atmosphere

13
00:00:51,580 --> 00:00:49,760

can tell us almost everything about the

14
00:00:55,450 --> 00:00:51,590
planet including a potential

15
00:00:58,000 --> 00:00:55,460
habitability a very important component

16
00:01:00,880 --> 00:00:58,010
of the atmosphere is the cloud clouds

17
00:01:03,190 --> 00:01:00,890
are almost exists on every solar system

18
00:01:06,160 --> 00:01:03,200
planets that had an atmosphere and have

19
00:01:08,499 --> 00:01:06,170
been observed on exoplanets it is very

20
00:01:11,469 --> 00:01:08,509
important because they have high albedo

21
00:01:14,109 --> 00:01:11,479
that can affect the energy balance and

22
00:01:18,280 --> 00:01:14,119
they can also infer the temperature

23
00:01:20,770 --> 00:01:18,290
profile and atmospheric dynamics but the

24
00:01:23,920 --> 00:01:20,780
thing is for now we don't have enough

25
00:01:26,800 --> 00:01:23,930
knowledge about cloud properties through

26
00:01:28,780 --> 00:01:26,810
the current observational data and we do

27
00:01:34,179 --> 00:01:28,790
hope to learn more about it in the

28
00:01:36,999 --> 00:01:34,189
future so in this talk our goal is to

29
00:01:38,830 --> 00:01:37,009
explore how much information and what

30
00:01:41,499 --> 00:01:38,840
kind of information about cloud

31
00:01:46,300 --> 00:01:41,509
properties we can get from the future

32
00:01:47,710 --> 00:01:46,310
dreams Webb Space Telescope the data I'm

33
00:01:49,539 --> 00:01:47,720
talking about is the transition

34
00:01:52,210 --> 00:01:49,549
transmission spectrum a lot of you

35
00:01:53,620 --> 00:01:52,220
should be familiar with this concept but

36
00:01:56,499 --> 00:01:53,630
since I have this slide I would just

37
00:01:59,050 --> 00:01:56,509
walk through a little bit so when our

38
00:02:02,649 --> 00:01:59,060

planet orbiting one of its hosts our

39
00:02:06,010 --> 00:02:02,659
transit occurs because there are many

40
00:02:08,800 --> 00:02:06,020
different gas species in the atmosphere

41
00:02:12,550 --> 00:02:08,810
they can absorb starlight at different

42
00:02:16,420 --> 00:02:12,560
wavelengths so we can observe the planet

43
00:02:19,300 --> 00:02:16,430
radius or the transit depth varying with

44
00:02:21,089 --> 00:02:19,310
the wavelength and that's what we call a

45
00:02:23,920 --> 00:02:21,099
transit transmission spectrum a

46
00:02:25,190 --> 00:02:23,930
transmission spectrum is essential in

47
00:02:26,960 --> 00:02:25,200
helping us to

48
00:02:28,820 --> 00:02:26,970
considering the assistance and the

49
00:02:32,600 --> 00:02:28,830
balances of chemicals in the atmosphere

50
00:02:34,630 --> 00:02:32,610
and it can also for potentially

51
00:02:38,420 --> 00:02:34,640
habitable planets you can also check the

52
00:02:41,270 --> 00:02:38,430
bow signatures or biomarkers to help

53
00:02:43,190 --> 00:02:41,280
assess the planetary environments but

54
00:02:45,589 --> 00:02:43,200
everything changed when coexist

55
00:02:47,470 --> 00:02:45,599
so clouds are very confusing in the

56
00:02:51,350 --> 00:02:47,480
transmission spectrum

57
00:02:53,750 --> 00:02:51,360
due to their high opacity they can they

58
00:02:58,610 --> 00:02:53,760
tend to block out a lot of the start

59
00:03:02,900 --> 00:02:58,620
light that can smear out the absorption

60
00:03:05,569 --> 00:03:02,910
features of the gas species so but

61
00:03:08,720 --> 00:03:05,579
hopefully with the launching of the

62
00:03:11,809 --> 00:03:08,730
James Webb telescope we can better

63
00:03:14,180 --> 00:03:11,819

characterize clouds in the transmission

64
00:03:17,410 --> 00:03:14,190
spectrum with higher resolution and

65
00:03:21,110 --> 00:03:17,420
signal-to-noise this figure shows the

66
00:03:24,110 --> 00:03:21,120
major instrument and a waistline

67
00:03:27,550 --> 00:03:24,120
coverage of the telescope from visible

68
00:03:30,050 --> 00:03:27,560
to mid infrared to do the better

69
00:03:32,780 --> 00:03:30,060
characterization of clouds we better

70
00:03:36,400 --> 00:03:32,790
first know what degree can Jada bless

71
00:03:40,309 --> 00:03:36,410
thee tell us about the cloud properties

72
00:03:43,430 --> 00:03:40,319
so to constrain cloud properties from

73
00:03:45,920 --> 00:03:43,440
the transmission spectrum we first need

74
00:03:47,900 --> 00:03:45,930
to know what clouds can do to the

75
00:03:50,960 --> 00:03:47,910
transmission spectrum so we use a

76
00:03:51,979 --> 00:03:50,970
radiative transfer for model with the

77
00:03:55,910 --> 00:03:51,989
input of gas

78
00:03:58,280 --> 00:03:55,920
gravity temperature profile and clouds

79
00:04:01,550 --> 00:03:58,290
to create a simulated transmission

80
00:04:04,789 --> 00:04:01,560
spectrum and the instrument model can

81
00:04:07,280 --> 00:04:04,799
noise up this transmission spectrum to

82
00:04:09,949 --> 00:04:07,290
mimic the real observational data and in

83
00:04:15,140 --> 00:04:09,959
this case the JWST transmission spectrum

84
00:04:17,270 --> 00:04:15,150
and then we can go ahead to such the

85
00:04:20,120 --> 00:04:17,280
information of cloud properties from

86
00:04:24,080 --> 00:04:20,130
this fake data and we'll use a Bayesian

87
00:04:26,060 --> 00:04:24,090
retrieval method to do it in this study

88
00:04:28,820 --> 00:04:26,070

we don't care about other inputs we only

89
00:04:31,760 --> 00:04:28,830
focus on the cloud parameters and we

90
00:04:35,690 --> 00:04:31,770
want to have a parameterised Klaus that

91
00:04:36,680 --> 00:04:35,700
is physically well motivated and also

92
00:04:40,370 --> 00:04:36,690
observable

93
00:04:43,460 --> 00:04:40,380
so we use four parameters to describe

94
00:04:46,760 --> 00:04:43,470
the cloud in the model the pressure

95
00:04:48,890 --> 00:04:46,770
level where the cloud base is and the

96
00:04:51,800 --> 00:04:48,900
mixing ratio of the common seats at the

97
00:04:54,080 --> 00:04:51,810
cloud based pressure and vertical

98
00:04:57,080 --> 00:04:54,090
profile index alpha to describe how the

99
00:04:59,770 --> 00:04:57,090
mixing ratio falls off with the high

100
00:05:02,810 --> 00:04:59,780
altitude and also there's one more

101
00:05:05,090 --> 00:05:02,820
parameters to describe the particle size

102
00:05:08,750 --> 00:05:05,100
of the cloud common say that is closely

103
00:05:14,990 --> 00:05:08,760
relevant to the optical properties of

104
00:05:19,600 --> 00:05:15,000
the common seat so in summary in our

105
00:05:22,580 --> 00:05:19,610
four model we include 15 gas species and

106
00:05:24,650 --> 00:05:22,590
we currently we are assuming typical

107
00:05:29,810 --> 00:05:24,660
atmospheric parameters for hot jupiter

108
00:05:31,900 --> 00:05:29,820
HD 20 9458 b note that we do not start

109
00:05:36,200 --> 00:05:31,910
with earth-like planets because they are

110
00:05:39,140 --> 00:05:36,210
difficult in observation and hot rivers

111
00:05:43,340 --> 00:05:39,150
are expected to more reach in terms of

112
00:05:45,770 --> 00:05:43,350
data so our first goal is to take a

113
00:05:49,610 --> 00:05:45,780

first glance of what can we learn about

114
00:05:51,530 --> 00:05:49,620
clouds from transmission spectrum in the

115
00:05:54,260 --> 00:05:51,540
case of a hot Jupiter and on top of

116
00:06:00,380 --> 00:05:54,270
these assumptions we add a parameterize

117
00:06:04,460 --> 00:06:00,390
cloud that we just described so with

118
00:06:06,950 --> 00:06:04,470
this input and through the four model we

119
00:06:11,630 --> 00:06:06,960
are able to generate the fake

120
00:06:15,860 --> 00:06:11,640
transmission spectrum of JWST here we

121
00:06:18,860 --> 00:06:15,870
assume a cloud composed of enstatite mg

122
00:06:26,370 --> 00:06:18,870
si of 3 with particle size of 0.1 micron

123
00:06:32,650 --> 00:06:30,490
the cloud-based pressure is 10 to the

124
00:06:36,010 --> 00:06:32,660
minus 2 bar with a mixing ratio of 10 to

125
00:06:37,930 --> 00:06:36,020
the minus 13 the cloud extends all the

126
00:06:41,080 --> 00:06:37,940
way from the cloud base to the top of

127
00:06:42,969 --> 00:06:41,090
the atmosphere the blue line shows the

128
00:06:45,340 --> 00:06:42,979
simulated transmission spectrum and

129
00:06:49,020 --> 00:06:45,350
these black dots with error bars out of

130
00:06:51,490 --> 00:06:49,030
fake data point we made the red curve is

131
00:06:53,710 --> 00:06:51,500
shows the contribution from the gas

132
00:06:55,810 --> 00:06:53,720
species and the green curve shows the

133
00:06:59,350 --> 00:06:55,820
contribution from the cloud common seeds

134
00:07:01,090 --> 00:06:59,360
know that the cloud of mainly affect the

135
00:07:02,260 --> 00:07:01,100
transmission spectrum at Short

136
00:07:04,960 --> 00:07:02,270
wavelengths with a Rayleigh scattering

137
00:07:08,490 --> 00:07:04,970
like feature and also at longer

138
00:07:11,110 --> 00:07:08,500

wavelength with a resonance feature and

139
00:07:13,740 --> 00:07:11,120
then we can go ahead to fetch

140
00:07:17,200 --> 00:07:13,750
information from these fake data we made

141
00:07:19,390 --> 00:07:17,210
using the Bayesian retrieval method that

142
00:07:22,029 --> 00:07:19,400
we know it's the Bayesian Retriever is

143
00:07:23,680 --> 00:07:22,039
based on Bayes theorem that we know the

144
00:07:26,590 --> 00:07:23,690
likelihood function the prior

145
00:07:29,830 --> 00:07:26,600
distribution of parameters and the

146
00:07:32,800 --> 00:07:29,840
evidence we can go ahead and derive the

147
00:07:34,930 --> 00:07:32,810
posterior distribution to be more

148
00:07:37,690 --> 00:07:34,940
straightforward the Bayesian receiver is

149
00:07:40,839 --> 00:07:37,700
to constrain Clow assumptions from the

150
00:07:43,629 --> 00:07:40,849
fake data so now we already generated

151
00:07:45,969 --> 00:07:43,639
the fake data which is cloudy from the

152
00:07:47,770 --> 00:07:45,979
fort model and now we're going to

153
00:07:50,650 --> 00:07:47,780
pretend we're ignorant about the cloud

154
00:07:52,930 --> 00:07:50,660
properties so we design experiments it

155
00:07:55,120 --> 00:07:52,940
has different cloud assumptions to do

156
00:07:57,460 --> 00:07:55,130
that we need to set the targeted

157
00:07:59,500 --> 00:07:57,470
parameters that we want to know free and

158
00:08:03,060 --> 00:07:59,510
let the retrieval model to find its best

159
00:08:06,460 --> 00:08:03,070
fit which is the posterior distribution

160
00:08:09,339 --> 00:08:06,470
in our first experiment we test the

161
00:08:12,129 --> 00:08:09,349
cloud free model on the cloudy fake data

162
00:08:16,450 --> 00:08:12,139
to see whether we can tell cloud exists

163
00:08:18,659 --> 00:08:16,460

from this data we choose temperature

164
00:08:20,980 --> 00:08:18,669
metallicity seed or ratio in the

165
00:08:24,370 --> 00:08:20,990
planet-sized scale as the targeted

166
00:08:26,740 --> 00:08:24,380
parameters and this is the stair pressed

167
00:08:29,620 --> 00:08:26,750
plot of the posterior distribution of

168
00:08:31,960 --> 00:08:29,630
these parameters from this comparison

169
00:08:34,959 --> 00:08:31,970
table we can see that the best feed

170
00:08:35,660 --> 00:08:34,969
values of these parameters all far off

171
00:08:38,150 --> 00:08:35,670
from the

172
00:08:42,470 --> 00:08:38,160
are true or input values in the fart

173
00:08:45,290 --> 00:08:42,480
model and then we can also take a look

174
00:08:48,830 --> 00:08:45,300
at the feeding this blue line is the

175
00:08:50,660 --> 00:08:48,840
feeding curve of the retrieval what is

176
00:08:53,960 --> 00:08:50,670
retrieved from the retrieval model and

177
00:08:56,750 --> 00:08:53,970
their queen dots are the big data points

178
00:08:59,300 --> 00:08:56,760
we can totally say this is a very bad

179
00:09:01,490 --> 00:08:59,310
feed and the Chi square is very large so

180
00:09:04,750 --> 00:09:01,500
the conclusion is that we can definitely

181
00:09:08,180 --> 00:09:04,760
tell Clow exist from the data we have

182
00:09:10,820 --> 00:09:08,190
the second in the second experiment we

183
00:09:13,480 --> 00:09:10,830
test with retrieve the parameterised

184
00:09:17,000 --> 00:09:13,490
cloud model on the cloudy fake data

185
00:09:19,430 --> 00:09:17,010
besides of the previous four basic

186
00:09:22,610 --> 00:09:19,440
parameters we also add the four cloudy

187
00:09:25,430 --> 00:09:22,620
meters to be retrieved apologize for

188
00:09:28,250 --> 00:09:25,440

their very small labels in a stereo spot

189
00:09:31,190 --> 00:09:28,260
but we can focus on the comparison table

190
00:09:33,740 --> 00:09:31,200
that these parameters being are

191
00:09:36,550 --> 00:09:33,750
retrieved their best to these values are

192
00:09:39,320 --> 00:09:36,560
very similar to their input values and

193
00:09:43,010 --> 00:09:39,330
if we take a look at the feeding curve

194
00:09:46,070 --> 00:09:43,020
we can say this is a very good fit with

195
00:09:48,650 --> 00:09:46,080
a small chi-square that we can conclude

196
00:09:52,640 --> 00:09:48,660
that the cloud parameters are well

197
00:09:55,790 --> 00:09:52,650
constrained from the data we have in the

198
00:09:59,480 --> 00:09:55,800
third experiment we test the gray cloud

199
00:10:02,410 --> 00:09:59,490
model under cloudy fake data the gray

200
00:10:06,290 --> 00:10:02,420
cloud model is a simplified cloud model

201
00:10:08,690 --> 00:10:06,300
that use three parameters the cloud top

202
00:10:12,110 --> 00:10:08,700
pressure the haze amplitude and hay

203
00:10:14,510 --> 00:10:12,120
slope to mimic the what usually the

204
00:10:16,820 --> 00:10:14,520
effect of clouds have on transmission

205
00:10:18,860 --> 00:10:16,830
spectrum that is a short wavelength

206
00:10:21,770 --> 00:10:18,870
slope and the flattening that in the

207
00:10:24,080 --> 00:10:21,780
shop in the longer wavelength and in the

208
00:10:26,120 --> 00:10:24,090
table we can see that temperature met

209
00:10:30,740 --> 00:10:26,130
with CC do ratio this important

210
00:10:33,680 --> 00:10:30,750
atmospheric premise they all deceive

211
00:10:37,370 --> 00:10:33,690
eiated from the true values in for the

212
00:10:40,460 --> 00:10:37,380
fort model but if we take a look at the

213
00:10:44,450 --> 00:10:40,470

feeding curve the situation is actually

214
00:10:48,080 --> 00:10:44,460
not that bad chi-square is not that

215
00:10:49,960 --> 00:10:48,090
large that is not very unacceptable the

216
00:11:00,170 --> 00:10:49,970
feeding

217
00:11:03,200 --> 00:11:00,180
might get tricked because the great

218
00:11:05,600 --> 00:11:03,210
clown model is providing us a very wrong

219
00:11:09,860 --> 00:11:05,610
information about of the atmosphere

220
00:11:12,140 --> 00:11:09,870
while feeding the data not very badly so

221
00:11:14,600 --> 00:11:12,150
at the current stage we have some

222
00:11:18,230 --> 00:11:14,610
conclusion but actually more questions

223
00:11:20,030 --> 00:11:18,240
in a specific case we test again we

224
00:11:22,910 --> 00:11:20,040
conclude that we can tell cloud exists

225
00:11:25,280 --> 00:11:22,920
and the cloud properties can be well

226
00:11:30,020 --> 00:11:25,290
well constrained from the fake data we

227
00:11:32,510 --> 00:11:30,030
made but however recorded the cloud we

228
00:11:34,820 --> 00:11:32,520
choose generate a resonance feature in

229
00:11:37,460 --> 00:11:34,830
the long wavelength that itself might be

230
00:11:40,220 --> 00:11:37,470
very unique that can help the cloud

231
00:11:43,430 --> 00:11:40,230
properties car parameters could be to be

232
00:11:45,140 --> 00:11:43,440
well constrained so we can ask the

233
00:11:47,810 --> 00:11:45,150
question like what if we only look at

234
00:11:49,790 --> 00:11:47,820
the short wavelengths or what if we

235
00:11:53,720 --> 00:11:49,800
choose something else that does not

236
00:11:56,300 --> 00:11:53,730
generate this resonance feature if that

237
00:11:58,490 --> 00:11:56,310
is especially for commented on

238
00:12:00,800 --> 00:11:58,500

earth-like planets

239
00:12:02,720 --> 00:12:00,810
another conclusion is that the great

240
00:12:04,910 --> 00:12:02,730
cloud model which is popular in

241
00:12:06,860 --> 00:12:04,920
atmospheric modeling it is actually

242
00:12:11,510 --> 00:12:06,870
dangerous to use at least in this case

243
00:12:13,910 --> 00:12:11,520
so but what if we had a big particle

244
00:12:16,730 --> 00:12:13,920
size cloud coexist with a small particle

245
00:12:18,740 --> 00:12:16,740
size cloud that is what the case that

246
00:12:21,740 --> 00:12:18,750
usually the great cloud model is trying

247
00:12:24,020 --> 00:12:21,750
to mimic would it provide correct

248
00:12:26,570 --> 00:12:24,030
information of the atmosphere so these

249
00:12:30,380 --> 00:12:26,580
are all the questions that we hope to

250
00:12:33,380 --> 00:12:30,390
explore more in the future we actually

251
00:12:36,290 --> 00:12:33,390
have a lot more experimental runs to

252
00:12:38,360 --> 00:12:36,300
come to answer questions like can we

253
00:12:40,460 --> 00:12:38,370
constrain particle size of condensate

254
00:12:43,940 --> 00:12:40,470
from data and can we tell there's a

255
00:12:48,890 --> 00:12:43,950
second Clow exist but more importantly

256
00:12:51,170 --> 00:12:48,900
we also start the series of experiments

257
00:12:56,210 --> 00:12:51,180
on the case of smaller and cooler

258
00:13:03,720 --> 00:12:56,220
planets with the same methodology thank

259
00:13:03,730 --> 00:13:11,420
good time for one or two questions

260
00:13:18,140 --> 00:13:15,530
great work you might want to look at how

261
00:13:21,079 --> 00:13:18,150
it how your constraints vary with the

262
00:13:23,240 --> 00:13:21,089
specific instrument spectral range that

263
00:13:26,450 --> 00:13:23,250

is appropriate for different jwc

264
00:13:29,960 --> 00:13:26,460
instruments for for example near spec

265
00:13:32,630 --> 00:13:29,970
only goes as several gratings 2.5 to 5

266
00:13:35,360 --> 00:13:32,640
so forth and so on and you could examine

267
00:13:37,400 --> 00:13:35,370
how your constraints you know benefit

268
00:13:39,230 --> 00:13:37,410
from different observations because you

269
00:13:41,720 --> 00:13:39,240
will never get that spectral range at

270
00:13:43,700 --> 00:13:41,730
one time so the question is how it

271
00:13:49,700 --> 00:13:43,710
depends on on what instrument reason

272
00:13:52,130 --> 00:13:49,710
yeah thanks we could possibly take one

273
00:13:55,280 --> 00:13:52,140
more quick question I have a quick

274
00:13:57,320 --> 00:13:55,290
question in the retrieval that included

275
00:14:00,650 --> 00:13:57,330
the climate seems like the cloud

276
00:14:02,720 --> 00:14:00,660
pressure base wasn't well retrieved are

277
00:14:03,170 --> 00:14:02,730
you just insensitive to the base of the

278
00:14:05,540 --> 00:14:03,180
cloud

279
00:14:11,300 --> 00:14:05,550
yeah actually do it at the time I skip

280
00:14:14,210 --> 00:14:11,310
that so it's not well retrieved due to a

281
00:14:17,750 --> 00:14:14,220
very specific reason just in this case

282
00:14:19,820 --> 00:14:17,760
so is actually because of an effect

283
00:14:22,370 --> 00:14:19,830
called a cloud based expect that

284
00:14:26,810 --> 00:14:22,380
generates a dip in the transmission

285
00:14:31,130 --> 00:14:26,820
spectrum and that feature is deeper that

286
00:14:33,890 --> 00:14:31,140
deeper than the water feature so when

287
00:14:36,860 --> 00:14:33,900
they overlap it kind of can't tell where

288
00:14:39,290 --> 00:14:36,870

the cloud base is so if you want more

289
00:14:43,390 --> 00:14:39,300
details I can explain look later yeah

290
00:14:44,440 --> 00:14:43,400
thank you let's thank young

291
00:14:45,650 --> 00:14:44,450
[Applause]