AbSciCon 2017

MESA, ARIZONA

1
00:00:06,160 --> 00:00:12,250
you

2
00:00:17,470 --> 00:00:14,640
[Music]

3
00:00:19,000 --> 00:00:17,480
Imaging habitable zone exoplanets and

4
00:00:20,500 --> 00:00:19,010
getting these reflectance spectra that

5
00:00:22,980 --> 00:00:20,510
we've been talking about so far will

6
00:00:25,960 --> 00:00:22,990
require a dedicated space space mission

7
00:00:28,599 --> 00:00:25,970
that hopefully will see fly in 20 years

8
00:00:30,460 --> 00:00:28,609
until then we can still study exoplanet

9
00:00:32,770 --> 00:00:30,470
answers even those in the habitable

10
00:00:33,670 --> 00:00:32,780
zones with the technique of transmission

11
00:00:35,860 --> 00:00:33,680
spectroscopy

12
00:00:37,660 --> 00:00:35,870
this is the multi wavelength study of

13
00:00:39,130 --> 00:00:37,670

exoplanets that transit directly in

14
00:00:44,610 --> 00:00:39,140
front of their stars from our point of

15
00:00:46,569 --> 00:00:44,620
view and that's all wavelengths the

16
00:00:47,920 --> 00:00:46,579
planet will block out sunlight and at

17
00:00:49,959 --> 00:00:47,930
some wavelengths the exoplanet will

18
00:00:52,270 --> 00:00:49,969
appear larger and the transit depth will

19
00:00:56,110 --> 00:00:52,280
be deeper because its atmosphere is

20
00:00:57,610 --> 00:00:56,120
absorbing or scattering light for

21
00:01:01,060 --> 00:00:57,620
example here's the transmission spectrum

22
00:01:03,570 --> 00:01:01,070
of Earth as shown here on the left if an

23
00:01:07,060 --> 00:01:03,580
alien astronomer were to look at earth

24
00:01:09,219 --> 00:01:07,070
in front of the Sun it would block out

25
00:01:11,350 --> 00:01:09,229
about 85 parts per million of the sun's

26
00:01:13,029 --> 00:01:11,360
light and at some wavelengths there'd be

27
00:01:17,010 --> 00:01:13,039
an additional one part per million

28
00:01:21,899 --> 00:01:17,020
blocked out by oxygen water carbon

29
00:01:27,880 --> 00:01:24,700
we'll call that additional decrease a

30
00:01:33,070 --> 00:01:27,890
delta D and the D is the regular transit

31
00:01:35,530 --> 00:01:33,080
depth so getting a successful detection

32
00:01:37,929 --> 00:01:35,540
of a one part per million feature is a

33
00:01:40,179 --> 00:01:37,939
really tall order but we can do better

34
00:01:42,280 --> 00:01:40,189
if we go to smaller stars because the

35
00:01:44,980 --> 00:01:42,290
scale of this effect scaled inversely

36
00:01:47,050 --> 00:01:44,990
with the radius squared of the star so

37
00:01:49,390 --> 00:01:47,060
for an M dwarf or early M dwarf we would

38
00:01:52,929 --> 00:01:49,400

get a three part per million Delta G and

39
00:01:55,600 --> 00:01:52,939
if we go to the latest M Dwarfs M 9 we

40
00:01:57,359 --> 00:01:55,610
can get a Delta G as large as 160 parts

41
00:01:59,679 --> 00:01:57,369
per million for an earth-like atmosphere

42
00:02:04,630 --> 00:01:59,689
which is detectable even with current

43
00:02:07,389 --> 00:02:04,640
fermentation very excitingly we now have

44
00:02:09,880 --> 00:02:07,399
some exoplanets around small stars that

45
00:02:11,350 --> 00:02:09,890
surveys have found recently dedicated

46
00:02:13,900 --> 00:02:11,360
surveys looking for these kinds of

47
00:02:15,340 --> 00:02:13,910
things that are going to be excellent

48
00:02:17,920 --> 00:02:15,350
targets for lists and we've heard about

49
00:02:19,390 --> 00:02:17,930
the traffic system which has seven

50
00:02:21,160 --> 00:02:19,400
roughly earth sized planets three of

51
00:02:24,720 --> 00:02:21,170
which could be in the habitable zone and

52
00:02:26,339 --> 00:02:24,730
just last week LHS 11:40

53
00:02:28,290 --> 00:02:26,349
II was announced today super-earth

54
00:02:31,740 --> 00:02:28,300
translating a mid M dwarf and his

55
00:02:33,930 --> 00:02:31,750
habitable zone so in the best-case

56
00:02:36,030 --> 00:02:33,940
scenario we would measure the transit

57
00:02:37,710 --> 00:02:36,040
depth at multiple wavelengths and any

58
00:02:40,860 --> 00:02:37,720
variations in the transit depth would be

59
00:02:43,380 --> 00:02:40,870
due to the planet's atmosphere but this

60
00:02:45,390 --> 00:02:43,390
assumes that the transit chord is

61
00:02:47,369 --> 00:02:45,400
exactly the same as the under coltd

62
00:02:49,710 --> 00:02:47,379
photosphere and this assumption is

63
00:02:51,509 --> 00:02:49,720

actually never correct it just depends

64
00:02:53,069 --> 00:02:51,519
on the precision we're interested in

65
00:02:57,390 --> 00:02:53,079
whether or not we just need to take this

66
00:03:00,479 --> 00:02:57,400
into account in reality stars are hot

67
00:03:02,220 --> 00:03:00,489
noisy chaotic places that make precise

68
00:03:03,569 --> 00:03:02,230
measurements very difficult as anyone

69
00:03:07,319 --> 00:03:03,579
that does radio velocity measurements

70
00:03:09,210 --> 00:03:07,329
can tell you and cool spots and hot

71
00:03:11,190 --> 00:03:09,220
stock you'll eat on the photosphere of

72
00:03:13,800 --> 00:03:11,200
the star that are not occulted by the

73
00:03:15,449 --> 00:03:13,810
exoplanet will not appear in our transit

74
00:03:18,599 --> 00:03:15,459
light curves but they will affect the

75
00:03:21,300 --> 00:03:18,609
transit depths we measure so even for

76
00:03:22,860 --> 00:03:21,310
relatively quiet stars any difference

77
00:03:25,380 --> 00:03:22,870
between the transit chord and the mean

78
00:03:29,580 --> 00:03:25,390
uh Nicole today sphere will be imprinted

79
00:03:31,110 --> 00:03:29,590
and our measurements from an

80
00:03:33,330 --> 00:03:31,120
illustration of the importance of this

81
00:03:36,659 --> 00:03:33,340
effect we have to look no farther than

82
00:03:39,960 --> 00:03:36,669
our own solar system this is the 2012

83
00:03:41,159 --> 00:03:39,970
transit of Venus as recorded at three

84
00:03:43,589 --> 00:03:41,169
different wavelengths from the extreme

85
00:03:48,210 --> 00:03:43,599
UV to the optical and you can tell by

86
00:03:49,589 --> 00:03:48,220
eye UV that the transit chord is not the

87
00:03:50,970 --> 00:03:49,599
same as the rest of the photosphere so

88
00:03:53,550 --> 00:03:50,980

if you're trying to measure the spectrum

89
00:03:55,849 --> 00:03:53,560
of Venus from these data it'd be very

90
00:03:58,680 --> 00:03:55,859
very difficult with the Sun

91
00:04:01,289 --> 00:03:58,690
heterogeneity it sounds actually a

92
00:04:05,460 --> 00:04:01,299
relatively quiet star it only varies its

93
00:04:07,770 --> 00:04:05,470
total radiance by about 0.1% whereas all

94
00:04:09,930 --> 00:04:07,780
these M dwarf host stars of these

95
00:04:12,569 --> 00:04:09,940
exciting exoplanets I'll demonstrate

96
00:04:17,159 --> 00:04:12,579
rotational modulations on the order of

97
00:04:20,159 --> 00:04:17,169
1% so this is commonly ripped

98
00:04:24,150 --> 00:04:20,169
interpreted as spots rotating in and out

99
00:04:26,850 --> 00:04:24,160
of our field of view but additionally

100
00:04:28,890 --> 00:04:26,860
how faculty can affect this and if there

101
00:04:31,290 --> 00:04:28,900
are axisymmetric features like

102
00:04:33,120 --> 00:04:31,300
latitudinal bands of spots those won't

103
00:04:34,560 --> 00:04:33,130
contribute to photometric modulation but

104
00:04:35,580 --> 00:04:34,570
they will impact the transmission

105
00:04:38,080 --> 00:04:35,590
spectrum

106
00:04:39,580 --> 00:04:38,090
so we have examples today with our

107
00:04:40,750 --> 00:04:39,590
current precision of transmission

108
00:04:44,050 --> 00:04:40,760
spectra that are affected by this

109
00:04:45,610 --> 00:04:44,060
there's the hot Jupiter HD 189 it's

110
00:04:48,250 --> 00:04:45,620
spectrum is shown here on the left and

111
00:04:51,400 --> 00:04:48,260
even after accounting for the rotational

112
00:04:54,280 --> 00:04:51,410
modulation of on occulted spots

113
00:04:56,200 --> 00:04:54,290

Nichola at all found that the remaining

114
00:04:58,360 --> 00:04:56,210
spectrum we see this strong optical

115
00:05:00,460 --> 00:04:58,370
slope can be explained by the presence

116
00:05:03,610 --> 00:05:00,470
of additional on occulted spots covering

117
00:05:06,040 --> 00:05:03,620
about 5% stellar disk and then some work

118
00:05:08,560 --> 00:05:06,050
that I led on the subnets here in GJ

119
00:05:11,620 --> 00:05:08,570
1214b we found that it's optical

120
00:05:13,390 --> 00:05:11,630
spectrum is sharply reduced and that is

121
00:05:18,850 --> 00:05:13,400
the effect of uh Nicole that's factually

122
00:05:20,500 --> 00:05:18,860
on its Middendorf co-star so before we

123
00:05:22,810 --> 00:05:20,510
set out to detect bio signatures from

124
00:05:25,060 --> 00:05:22,820
work like exoplanets we need to ask

125
00:05:26,650 --> 00:05:25,070
ourselves how my stellar heterogeneity

126
00:05:29,560 --> 00:05:26,660
affect these high-precision measurements

127
00:05:31,000 --> 00:05:29,570
so today and we're simulating the

128
00:05:34,780 --> 00:05:31,010
signals produced by host arts for a

129
00:05:37,240 --> 00:05:34,790
variety of situations there are two

130
00:05:39,340 --> 00:05:37,250
proposed observational designs I want to

131
00:05:40,900 --> 00:05:39,350
talk about here one is going to space

132
00:05:42,670 --> 00:05:40,910
with the James Webb Space Telescope and

133
00:05:46,030 --> 00:05:42,680
getting a low resolution spectrum from

134
00:05:49,180 --> 00:05:46,040
the 0.62 5.3 microns we can look for

135
00:05:52,450 --> 00:05:49,190
absorption from o2 water carbon dioxide

136
00:05:54,400 --> 00:05:52,460
and another idea is using a ground-based

137
00:05:56,800 --> 00:05:54,410
giant telescope like giant intelligent

138
00:05:59,440 --> 00:05:56,810

Magellan telescope getting a very

139
00:06:02,260 --> 00:05:59,450
high-resolution spectrum and then

140
00:06:05,080 --> 00:06:02,270
actually we can detect the oxygen to a

141
00:06:06,520 --> 00:06:05,090
band in the exoplanet atmosphere because

142
00:06:08,260 --> 00:06:06,530
the radio velocity of the planet and

143
00:06:10,990 --> 00:06:08,270
star will shift those lines away from

144
00:06:14,580 --> 00:06:11,000
the lines and our atmosphere and we can

145
00:06:17,980 --> 00:06:14,590
peer between our lines and examine those

146
00:06:20,860 --> 00:06:17,990
so we examined these two scenarios for a

147
00:06:23,080 --> 00:06:20,870
range of spectral types with a earthlike

148
00:06:26,380 --> 00:06:23,090
exoplanet orbiting them and then

149
00:06:29,800 --> 00:06:26,390
simulated the effect of 2% spots and 2%

150
00:06:32,350 --> 00:06:29,810
faculty and these roughly produce the 1%

151
00:06:34,480 --> 00:06:32,360
photometric modulations that we see from

152
00:06:36,580 --> 00:06:34,490
these stars so just stepping through the

153
00:06:39,100 --> 00:06:36,590
results in the near infrared we're

154
00:06:41,650 --> 00:06:39,110
looking at the effective spots I'm

155
00:06:44,590 --> 00:06:41,660
showing here the Delta D produced as a

156
00:06:46,360 --> 00:06:44,600
function of wavelength and gray is shown

157
00:06:49,570 --> 00:06:46,370
the transmission spectrum of earth just

158
00:06:52,749 --> 00:06:49,580
as guide your eye the scales arbitrary

159
00:06:54,100 --> 00:06:52,759
for a k0 dwarf the actual amplitude of

160
00:06:55,869 --> 00:06:54,110
these features is about one part per

161
00:06:57,909 --> 00:06:55,879
million that's the blue shaded region

162
00:07:00,399 --> 00:06:57,919
you can barely see and the effect

163
00:07:02,469 --> 00:07:00,409

produced by two percent spot coverage is

164
00:07:07,089 --> 00:07:02,479
about 25 parts per million that's the

165
00:07:08,770 --> 00:07:07,099
blue line if we go to cooler stars we

166
00:07:11,110 --> 00:07:08,780
can get a larger bio signature because

167
00:07:15,430 --> 00:07:11,120
this star smaller but the effect of the

168
00:07:17,350 --> 00:07:15,440
stars heterogeneity is also larger by

169
00:07:20,140 --> 00:07:17,360
the time we get to the mid the M dwarfs

170
00:07:22,089 --> 00:07:20,150
these stars are cool enough that there's

171
00:07:24,820 --> 00:07:22,099
differences in molecular opacity between

172
00:07:26,200 --> 00:07:24,830
the photosphere of the spots and on the

173
00:07:28,510 --> 00:07:26,210
parts per million level those

174
00:07:31,600 --> 00:07:28,520
differences are imparted onto the

175
00:07:33,790 --> 00:07:31,610
spectra that we see and unfortunately

176
00:07:38,010 --> 00:07:33,800
overlap molecular features we're trying

177
00:07:40,689 --> 00:07:38,020
to get from the exoplanet we go to mid M

178
00:07:43,659 --> 00:07:40,699
dwarfs its situation is the same except

179
00:07:45,879 --> 00:07:43,669
now we're getting a much larger Delta G

180
00:07:47,950 --> 00:07:45,889
produced by the planet that's that's

181
00:07:51,249 --> 00:07:47,960
going to help us and finally it's a very

182
00:07:51,850 --> 00:07:51,259
coolest M dwarf our Delta G from the

183
00:07:54,219 --> 00:07:51,860
planet

184
00:07:56,980 --> 00:07:54,229
finally overcomes the Delta G produced

185
00:07:58,629 --> 00:07:56,990
by the star but still we're looking at a

186
00:08:00,580 --> 00:07:58,639
Stiller signal that's a significant

187
00:08:04,180 --> 00:08:00,590
fraction of the planetary signal we're

188
00:08:06,279 --> 00:08:04,190

trying to measure for the case of faculy

189
00:08:09,399 --> 00:08:06,289
it's pretty much the same but in Reverse

190
00:08:11,800 --> 00:08:09,409
faculty will decrease your transit

191
00:08:16,870 --> 00:08:11,810
deaths so we have negative Delta DS here

192
00:08:19,120 --> 00:08:16,880
and it's largely a relatively flat

193
00:08:21,610 --> 00:08:19,130
signal for the larger stars and when you

194
00:08:25,779 --> 00:08:21,620
get to cool stars faculty can impart

195
00:08:27,550 --> 00:08:25,789
molecular features on your spectra so

196
00:08:31,120 --> 00:08:27,560
what if we look at high-resolution

197
00:08:35,110 --> 00:08:31,130
optical measurements so here I'm showing

198
00:08:37,690 --> 00:08:35,120
a much higher resolution spectrum we're

199
00:08:41,260 --> 00:08:37,700
only looking at point zero one microns

200
00:08:43,930 --> 00:08:41,270
instead of five microns and in grey this

201
00:08:45,880 --> 00:08:43,940
is the structure of the oxygen to a band

202
00:08:47,920 --> 00:08:45,890
at an arbitrary scale again it's

203
00:08:51,069 --> 00:08:47,930
actually one part per million at this

204
00:08:53,980 --> 00:08:51,079
level for the k0 Dorf we get a signal

205
00:08:55,900 --> 00:08:53,990
from the star that's pretty flat across

206
00:08:57,699 --> 00:08:55,910
this narrow range which is good might be

207
00:09:00,660 --> 00:08:57,709
easy to take out but it's about 80 times

208
00:09:02,880 --> 00:09:00,670
larger than the planetary signal

209
00:09:04,950 --> 00:09:02,890
and the picture the same as you go to

210
00:09:07,410 --> 00:09:04,960
cooler Dwarfs you start getting more and

211
00:09:14,040 --> 00:09:07,420
more molecular features and parted on to

212
00:09:18,290 --> 00:09:14,050
your spectra and unfortunately the o2 a

213
00:09:22,350 --> 00:09:18,300

van is in the same spectral space as the

214
00:09:24,540 --> 00:09:22,360
strong potassium doublet and for mid and

215
00:09:27,600 --> 00:09:24,550
late M dwarfs there's differences in

216
00:09:29,970 --> 00:09:27,610
potassium opacity that can change your

217
00:09:34,950 --> 00:09:29,980
spectra on the order of 100 parts per

218
00:09:38,400 --> 00:09:34,960
million and again vacuole II have the

219
00:09:40,700 --> 00:09:38,410
opposite effect and since I'm just using

220
00:09:43,980 --> 00:09:40,710
two percent faculty in two percent spots

221
00:09:46,080 --> 00:09:43,990
faculty are hotter they can put out more

222
00:09:49,530 --> 00:09:46,090
stellar light so they end up making a

223
00:09:52,710 --> 00:09:49,540
larger impact just assuming two percent

224
00:09:55,320 --> 00:09:52,720
coverage and we can for the mid and late

225
00:09:57,270 --> 00:09:55,330
M dwarf so we can change our transit

226
00:10:02,760 --> 00:09:57,280
depth on the order of thousands of parts

227
00:10:06,270 --> 00:10:02,770
per million so to summarize we looked at

228
00:10:09,060 --> 00:10:06,280
K 0 to M 9 and we simulated the effect

229
00:10:10,980 --> 00:10:09,070
of spots and this kind of spot coverage

230
00:10:13,920 --> 00:10:10,990
if you integrate it over the Iban would

231
00:10:17,310 --> 00:10:13,930
produce a rotational variation on the

232
00:10:18,840 --> 00:10:17,320
order of a half to 1% and the signals

233
00:10:22,470 --> 00:10:18,850
we'd be looking from the planet are

234
00:10:25,560 --> 00:10:22,480
about 1 to 160 parts per million and the

235
00:10:27,690 --> 00:10:25,570
near-infrared the stellar signal from

236
00:10:30,750 --> 00:10:27,700
that corresponds of these variabilities

237
00:10:34,050 --> 00:10:30,760
is much larger than the planetary signal

238
00:10:36,090 --> 00:10:34,060

for all but the latest M dwarfs and in

239
00:10:42,030 --> 00:10:36,100
the optical the stellar signal is always

240
00:10:45,600 --> 00:10:42,040
larger picture is the same for faculty

241
00:10:47,730 --> 00:10:45,610
but was reduced but with opposite signs

242
00:10:49,230 --> 00:10:47,740
and the effects a little bit larger

243
00:10:51,120 --> 00:10:49,240
because I'm just again assuming 2

244
00:10:54,810 --> 00:10:51,130
percent coverage not scaling for the

245
00:10:55,800 --> 00:10:54,820
actual photometry so the main point you

246
00:10:58,380 --> 00:10:55,810
should take away from this is that

247
00:11:00,270 --> 00:10:58,390
stellar photo spheric heterogeneity

248
00:11:02,520 --> 00:11:00,280
detects all transmission spectra and

249
00:11:04,590 --> 00:11:02,530
it's just a it's a matter of scale and

250
00:11:07,170 --> 00:11:04,600
when we try to get these really high

251
00:11:09,150 --> 00:11:07,180
precision measurements from exoplanets

252
00:11:12,480 --> 00:11:09,160
it's going to affect all transmission

253
00:11:14,220 --> 00:11:12,490
spectra that we try to get variability

254
00:11:16,830 --> 00:11:14,230
on the 1% level

255
00:11:19,080 --> 00:11:16,840
we'll pit two spectral features in your

256
00:11:21,900 --> 00:11:19,090
near infrared spectra on the 10 to 100

257
00:11:24,630 --> 00:11:21,910
ppm level and unfortunately the

258
00:11:27,000 --> 00:11:24,640
potassium doublet and the coincidence of

259
00:11:29,720 --> 00:11:27,010
the oxygen to a band is going to really

260
00:11:35,520 --> 00:11:29,730
complicate optical high-resolution

261
00:11:37,050 --> 00:11:35,530
observations so as we're planning to

262
00:11:40,440 --> 00:11:37,060
take these destined to get

263
00:11:42,600 --> 00:11:40,450

high-precision measurements of exoplanet

264
00:11:45,060 --> 00:11:42,610
atmospheres we should also try to

265
00:11:47,580 --> 00:11:45,070
understand stellar photo spheres to that

266
00:11:54,360 --> 00:11:47,590
same level of precision and thank you

267
00:11:56,880 --> 00:11:54,370
for your attention we have time for a

268
00:11:59,580 --> 00:11:56,890
couple questions and I want to start

269
00:12:02,910 --> 00:11:59,590
with one which is did you look at the

270
00:12:04,470 --> 00:12:02,920
point 6 9 micron oxygen ban or the 1.2 7

271
00:12:06,090 --> 00:12:04,480
micron oxygen band which may not have

272
00:12:08,690 --> 00:12:06,100
the problems with the potassium doubled

273
00:12:12,630 --> 00:12:08,700
overlap I only looked at the point 6 9

274
00:12:15,060 --> 00:12:12,640
for this because that was the the ideas

275
00:12:16,740 --> 00:12:15,070
you could get it from the ground with

276
00:12:19,380 --> 00:12:16,750
the high resolution measurement I

277
00:12:22,040 --> 00:12:19,390
haven't looked at the near-infrared

278
00:12:28,950 --> 00:12:22,050
oxygen Banias thank you as well

279
00:12:31,890 --> 00:12:28,960
yeah on ok thanks for the great talk um

280
00:12:33,960 --> 00:12:31,900
it seems though that observing the

281
00:12:36,510 --> 00:12:33,970
parent star and having a good

282
00:12:38,610 --> 00:12:36,520
understanding of spectral features for

283
00:12:41,400 --> 00:12:38,620
stellar atmospheres can just help you

284
00:12:43,320 --> 00:12:41,410
remove or account for these effects you

285
00:12:45,360 --> 00:12:43,330
you have variability of course which is

286
00:12:47,700 --> 00:12:45,370
the key factor but otherwise they're

287
00:12:49,980 --> 00:12:47,710
stable if they're stable you can just

288
00:12:51,840 --> 00:12:49,990

account for them in your modeling and

289
00:12:54,780 --> 00:12:51,850
you'll still see the transit feature in

290
00:12:57,300 --> 00:12:54,790
the same way that correcting explain how

291
00:12:59,130 --> 00:12:57,310
exactly it would affect in different

292
00:13:02,420 --> 00:12:59,140
circumstances your final results yeah

293
00:13:06,510 --> 00:13:02,430
so the complicated thing is with

294
00:13:09,300 --> 00:13:06,520
photometry we're we're what we have to

295
00:13:11,550 --> 00:13:09,310
assume is that the brightest photometry

296
00:13:13,620 --> 00:13:11,560
we see corresponds to an immaculate

297
00:13:16,320 --> 00:13:13,630
photosphere with no features and that's

298
00:13:19,080 --> 00:13:16,330
kind of in the case of 189 to hot

299
00:13:20,940 --> 00:13:19,090
Jupiter spectrum that I showed that was

300
00:13:24,000 --> 00:13:20,950
the assumption that the authors took so

301
00:13:24,560 --> 00:13:24,010
we have a we have immaculate photosphere

302
00:13:26,690 --> 00:13:24,570
and then

303
00:13:28,520 --> 00:13:26,700
at the different points that we measured

304
00:13:29,870 --> 00:13:28,530
our actual data we can take the

305
00:13:32,480 --> 00:13:29,880
brightness of the star at that point and

306
00:13:35,150 --> 00:13:32,490
correct for they set and they did that

307
00:13:37,340 --> 00:13:35,160
they thought that the cellar photos

308
00:13:39,080 --> 00:13:37,350
great had about two percent coverage but

309
00:13:41,480 --> 00:13:39,090
Nicola doll showed that in reality

310
00:13:44,620 --> 00:13:41,490
there's there's a latitudinal ban of uh

311
00:13:47,690 --> 00:13:44,630
Nicole tada that don't contribute the

312
00:13:49,790 --> 00:13:47,700
photometric modulations because they are

313
00:13:52,820 --> 00:13:49,800

actually symmetric and they are

314
00:13:56,870 --> 00:13:52,830
affecting the riffle resulting spectrum

315
00:13:59,390 --> 00:13:56,880
so there one way we can attack this is

316
00:14:02,210 --> 00:13:59,400
we could we can get much longer

317
00:14:04,250 --> 00:14:02,220
photometric monitoring campaigns and we

318
00:14:05,480 --> 00:14:04,260
can you know increase our chances that

319
00:14:07,790 --> 00:14:05,490
we're actually going to see the star

320
00:14:10,340 --> 00:14:07,800
when it has this immaculate photosphere

321
00:14:11,750 --> 00:14:10,350
we have our zero point but other than

322
00:14:14,560 --> 00:14:11,760
that if we don't know what the zero

323
00:14:17,690 --> 00:14:14,570
point is it's not going to be possible

324
00:14:20,240 --> 00:14:17,700
maybe Doppler imaging of stars can help

325
00:14:22,670 --> 00:14:20,250
us get to that I think you want really

326
00:14:25,040 --> 00:14:22,680
quick much simply just quickly nice

327
00:14:27,050 --> 00:14:25,050
simulations I think would be important

328
00:14:29,180 --> 00:14:27,060
to include magnetic fields because they

329
00:14:31,790 --> 00:14:29,190
will affect the depth of the molecular

330
00:14:33,860 --> 00:14:31,800
bands which you calculated that will be

331
00:14:35,060 --> 00:14:33,870
for M dwarfs very important yeah yeah

332
00:14:36,590 --> 00:14:35,070
I'd love to talk to you about that I'm