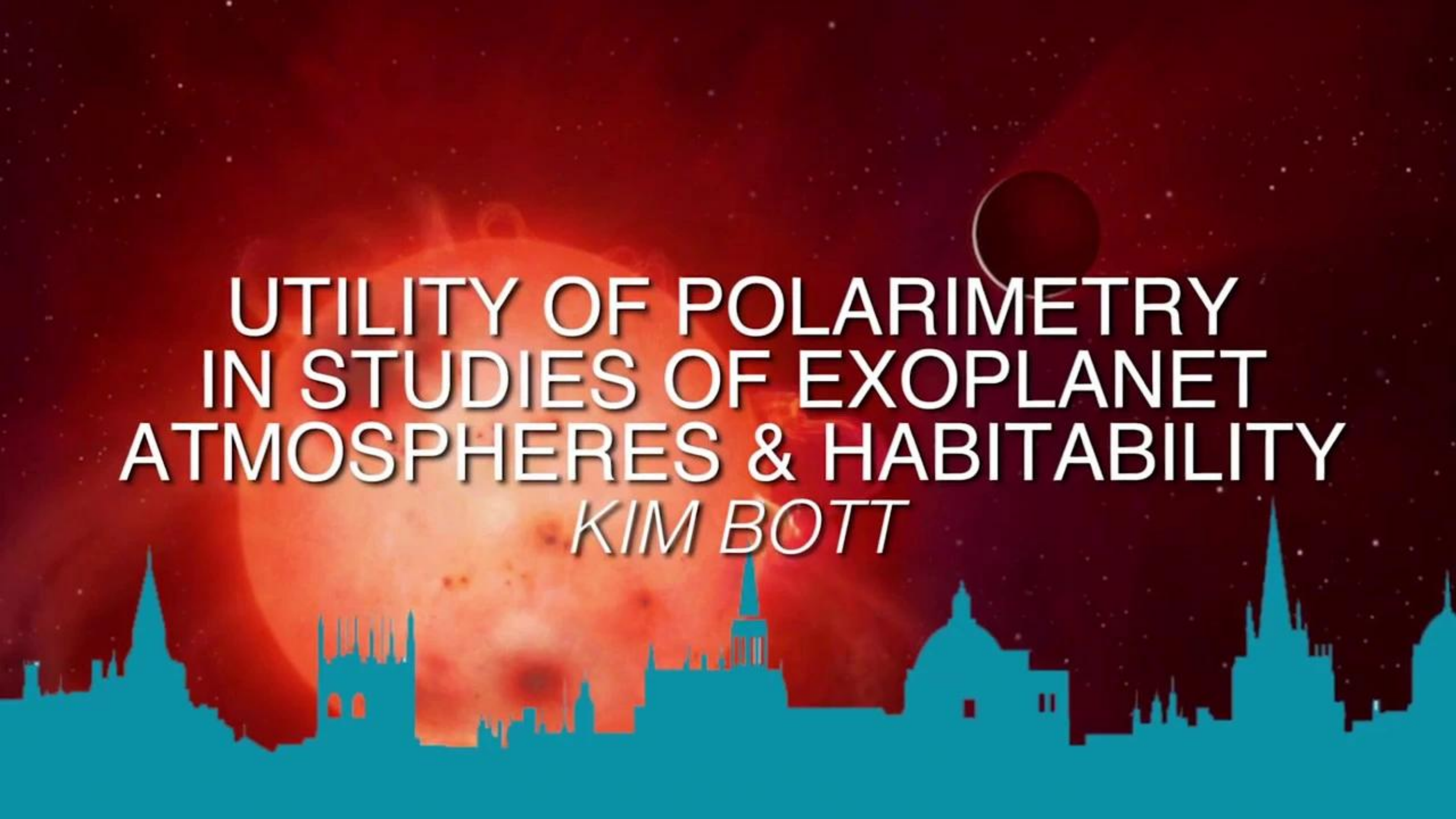
UTILITY OF POLARIMETRY
IN STUDIES OF EXOPLANET
ATMOSPHERES & HABITABILITY
KIM BOTT

1
00:00:01,350 --> 00:00:15,190
[Music]

2
00:00:21,470 --> 00:00:19,880
how about now okay okay so thanks

3
00:00:27,980 --> 00:00:21,480
everyone for staying for the last few

4
00:00:29,560 --> 00:00:27,990
talks of the session I'm Bea I'll be

5
00:00:32,269 --> 00:00:29,570
talking to you guys today about

6
00:00:35,840 --> 00:00:32,279
polarimetry it's one cool trick that has

7
00:00:37,729 --> 00:00:35,850
moms everywhere mad and it's really not

8
00:00:39,049 --> 00:00:37,739
used as much as it should be it's

9
00:00:41,720 --> 00:00:39,059
probably something that you heard about

10
00:00:43,850 --> 00:00:41,730
while you were an undergraduate and have

11
00:00:45,140 --> 00:00:43,860
since completely forgotten about because

12
00:00:46,360 --> 00:00:45,150
most of us aren't using it in our

13
00:00:49,250 --> 00:00:46,370

research

14
00:00:52,100 --> 00:00:49,260
the idea with polarimetry is really just

15
00:00:55,880 --> 00:00:52,110
that instead of thinking of life as just

16
00:00:57,320 --> 00:00:55,890
a scalar with intensity and wavelength

17
00:00:59,780 --> 00:00:57,330
information that you think of it as a

18
00:01:01,250 --> 00:00:59,790
vector so you still have that scalar

19
00:01:04,850 --> 00:01:01,260
information but you also have

20
00:01:06,770 --> 00:01:04,860
information about your electric field

21
00:01:09,320 --> 00:01:06,780
oscillation so it's your electromagnetic

22
00:01:11,240 --> 00:01:09,330
wave having an electric field on

23
00:01:14,539 --> 00:01:11,250
oscillates up and down side aside in a

24
00:01:21,889 --> 00:01:14,549
corkscrew Plus polarimetry in terms of

25
00:01:25,069 --> 00:01:21,899
observing a planet in terms of observing

26
00:01:28,060 --> 00:01:25,079
a planet what we are going to have at

27
00:01:30,800 --> 00:01:28,070
least in an ideal case with a nice calm

28
00:01:32,630 --> 00:01:30,810
main-sequence star it's unpolarized

29
00:01:33,889 --> 00:01:32,640
incident light coming from my star and

30
00:01:37,120 --> 00:01:33,899
that's going to be scattering off a

31
00:01:39,289 --> 00:01:37,130
surface or off of an atmosphere and that

32
00:01:41,959 --> 00:01:39,299
scattering or reflection is going to

33
00:01:44,630 --> 00:01:41,969
impart a trend in the way that the

34
00:01:46,130 --> 00:01:44,640
electric field oscillates and so it's

35
00:01:49,219 --> 00:01:46,140
going to give us great contrast with our

36
00:01:51,499 --> 00:01:49,229
stars in those cases I'm talking mostly

37
00:01:54,050 --> 00:01:51,509
about habitability today but I wanted to

38
00:01:56,230 --> 00:01:54,060

touch on these other things that

39
00:01:58,370 --> 00:01:56,240
polarimetry has contributed to

40
00:02:02,779 --> 00:01:58,380
polarimetry has allowed us to constrain

41
00:02:05,359 --> 00:02:02,789
albedo of ht1 8-9 7:33 be the original

42
00:02:07,760 --> 00:02:05,369
claim detection of polarized light from

43
00:02:09,919 --> 00:02:07,770
that planet is disputed but those non

44
00:02:11,960 --> 00:02:09,929
detection that dispute that have given

45
00:02:14,650 --> 00:02:11,970
us some physical constraints on the

46
00:02:17,870 --> 00:02:14,660
nature of the planet more recently

47
00:02:20,240 --> 00:02:17,880
observations in polarized light of the

48
00:02:23,059 --> 00:02:20,250
other ha Jupiter I have up there wasp

49
00:02:26,300 --> 00:02:23,069
18b have allowed us to exclude certain

50
00:02:28,280 --> 00:02:26,310
scenarios Venus of course was famously

51
00:02:29,839 --> 00:02:28,290
observed and polarized like many times

52
00:02:32,690 --> 00:02:29,849
and that allowed us to determine what

53
00:02:35,569 --> 00:02:32,700
the cloud species was dominant in that

54
00:02:38,929 --> 00:02:35,579
atmosphere that that was not a nice

55
00:02:41,270 --> 00:02:38,939
jungle planet right next door to us in

56
00:02:43,640 --> 00:02:41,280
the case of Titan polarimetry was used

57
00:02:45,979 --> 00:02:43,650
to give us the first indication that

58
00:02:48,110 --> 00:02:45,989
this was a cloudy hazy world and that

59
00:02:51,020 --> 00:02:48,120
unusual photometry that we saw from that

60
00:02:53,030 --> 00:02:51,030
was not because we had snow all over the

61
00:02:54,860 --> 00:02:53,040
surface that's a really interesting

62
00:02:58,069 --> 00:02:54,870
paper by the way if you look it up

63
00:03:01,129 --> 00:02:58,079

Illinois 1973 very recently we've had

64
00:03:03,649 --> 00:03:01,139
observations of solar oblate notes from

65
00:03:05,360 --> 00:03:03,659
rapidly rotating stars even seeing stars

66
00:03:07,849 --> 00:03:05,370
reflecting each other's light in

67
00:03:09,470 --> 00:03:07,859
polarized light and we've had a lot of

68
00:03:11,780 --> 00:03:09,480
characterization of the interstellar

69
00:03:15,440 --> 00:03:11,790
medium which is a really vital component

70
00:03:16,640 --> 00:03:15,450
to studies of exoplanets the polarized

71
00:03:17,509 --> 00:03:16,650
light that's something that we need to

72
00:03:30,110 --> 00:03:17,519
take into account

73
00:03:33,920 --> 00:03:30,120
oh is it thanks okay that sounds better

74
00:03:36,649 --> 00:03:33,930
yeah all right so as we have a planet

75
00:03:39,080 --> 00:03:36,659
that's moving through its phases around

76
00:03:40,969 --> 00:03:39,090
its star we're going to see these key

77
00:03:43,099 --> 00:03:40,979
features come up in polarized light

78
00:03:46,369 --> 00:03:43,109
coming from glint off an ocean if it has

79
00:03:47,719 --> 00:03:46,379
a rainbow from other optical effects

80
00:03:50,330 --> 00:03:47,729
from clouds and from Rayleigh scattering

81
00:03:51,890 --> 00:03:50,340
and depending out what wavelengths are

82
00:03:53,899 --> 00:03:51,900
looking at different features we'll be

83
00:03:55,550 --> 00:03:53,909
dominant so that allows us to

84
00:03:57,860 --> 00:03:55,560
characterize the exoplanets around their

85
00:03:59,629 --> 00:03:57,870
star there's also some stuff that you

86
00:04:01,369 --> 00:03:59,639
can do as far as bio signatures looking

87
00:04:02,809 --> 00:04:01,379
for chiral molecules so I'm not really

88
00:04:04,490 --> 00:04:02,819

going to talk about that today but I

89
00:04:07,670 --> 00:04:04,500
just wanted to leave it up to remind

90
00:04:09,500 --> 00:04:07,680
people to look it up so one of the

91
00:04:11,479 --> 00:04:09,510
strengths of this as I have touched on

92
00:04:13,670 --> 00:04:11,489
before is that you can naturally know

93
00:04:15,559 --> 00:04:13,680
that star if it's a calm star you're

94
00:04:17,629 --> 00:04:15,569
going to create natural contrast with it

95
00:04:20,420 --> 00:04:17,639
so you don't necessarily need to use

96
00:04:21,830 --> 00:04:20,430
something like a coronagraph you don't

97
00:04:23,390 --> 00:04:21,840
necessarily need your planet to be

98
00:04:25,640 --> 00:04:23,400
transiting the star for you to be able

99
00:04:27,650 --> 00:04:25,650
to characterize it

100
00:04:29,960 --> 00:04:27,660
another benefit is that you can derive

101
00:04:32,360 --> 00:04:29,970
orbital parameters even for planets that

102
00:04:34,640 --> 00:04:32,370
do not transit there start your

103
00:04:37,040 --> 00:04:34,650
inclination is going to change the shape

104
00:04:38,330 --> 00:04:37,050
of your polarized light curve not just

105
00:04:39,800 --> 00:04:38,340
the intensity but the shape of your

106
00:04:43,310 --> 00:04:39,810
polarized light curve so that can be

107
00:04:46,129 --> 00:04:43,320
figured out using this method polarized

108
00:04:47,570 --> 00:04:46,139
light really lends itself to confirming

109
00:04:49,520 --> 00:04:47,580
the presence of clouds as well and

110
00:04:52,100 --> 00:04:49,530
possibly to characterizing them if you

111
00:04:54,170 --> 00:04:52,110
can get enough data for that so I'm

112
00:04:57,250 --> 00:04:54,180
going to show you a few models most of

113
00:04:59,810 --> 00:04:57,260

these models are going to be based on

114
00:05:02,540 --> 00:04:59,820
chemically evolved models from and

115
00:05:04,159 --> 00:05:02,550
ruling house keys 2018 papers so he was

116
00:05:06,680 --> 00:05:04,169
looking at the Trappist one system and

117
00:05:10,580 --> 00:05:06,690
the kind of archetype planets that we

118
00:05:11,689 --> 00:05:10,590
might find there so in these graphs that

119
00:05:13,580 --> 00:05:11,699
I'm going to show you in a little bit

120
00:05:15,230 --> 00:05:13,590
we're going to be taking a few of these

121
00:05:15,680 --> 00:05:15,240
archetypes and comparing them to each

122
00:05:18,080 --> 00:05:15,690
other

123
00:05:19,700 --> 00:05:18,090
maybe including things like varying

124
00:05:21,560 --> 00:05:19,710
types of clouds and adding cloud cases

125
00:05:24,230 --> 00:05:21,570
we're not going to talk about services

126
00:05:27,230 --> 00:05:24,240
in too much detail but the question was

127
00:05:28,879 --> 00:05:27,240
if we have this information from the

128
00:05:30,770 --> 00:05:28,889
scalar components things like the albedo

129
00:05:34,760 --> 00:05:30,780
of these different surfaces and the

130
00:05:37,159 --> 00:05:34,770
behavior in scalar light of atmospheres

131
00:05:38,900 --> 00:05:37,169
and of different types of clouds what

132
00:05:41,420 --> 00:05:38,910
more can we know by looking at this in

133
00:05:43,640 --> 00:05:41,430
polarized light so we have that for

134
00:05:46,100 --> 00:05:43,650
comparison in scalar light we also have

135
00:05:47,990 --> 00:05:46,110
very different behavior of surfaces in

136
00:05:49,779 --> 00:05:48,000
polarized light different surfaces

137
00:05:53,360 --> 00:05:49,789
polarized light in different ways and

138
00:05:55,640 --> 00:05:53,370

even different types of ices can

139
00:05:57,350 --> 00:05:55,650
polarize light in slightly different

140
00:06:00,650 --> 00:05:57,360
ways which could be vital in the far

141
00:06:03,230 --> 00:06:00,660
future for characterizing some types of

142
00:06:04,820 --> 00:06:03,240
exoplanets but is immediately useful for

143
00:06:08,659 --> 00:06:04,830
characterizing the icy moons in our own

144
00:06:11,270 --> 00:06:08,669
solar system for the plots I'm about to

145
00:06:13,969 --> 00:06:11,280
show you this is just a dummy plot I

146
00:06:15,860 --> 00:06:13,979
just wanted to point out that the x-axis

147
00:06:17,420 --> 00:06:15,870
it's typically going to be just half of

148
00:06:20,779 --> 00:06:17,430
an orbit so we're going from full phase

149
00:06:22,490 --> 00:06:20,789
to new phase the y-axis is polarization

150
00:06:23,930 --> 00:06:22,500
and parts per million so that's telling

151
00:06:25,939 --> 00:06:23,940
us the size of the signal current

152
00:06:30,379 --> 00:06:25,949
polarimeters are sensitive to about one

153
00:06:32,930 --> 00:06:30,389
part per million and then at the top

154
00:06:34,399 --> 00:06:32,940
I've merged some small end with the

155
00:06:37,130 --> 00:06:34,409
dashed lines I've merged some key

156
00:06:38,590 --> 00:06:37,140
features to look for I just want to

157
00:06:42,070 --> 00:06:38,600
point out that the

158
00:06:43,620 --> 00:06:42,080
maximum polarization is not necessarily

159
00:06:45,430 --> 00:06:43,630
the same as where we find the maximum

160
00:06:47,980 --> 00:06:45,440
signal we need to combine the

161
00:06:48,730 --> 00:06:47,990
polarization in some cases with the

162
00:06:50,650 --> 00:06:48,740
amount of light that we're getting

163
00:06:52,120 --> 00:06:50,660

reflected off the planet and if we're

164
00:06:54,070 --> 00:06:52,130
looking at a rainbow that that might

165
00:06:55,090 --> 00:06:54,080
shift depending on the species producing

166
00:06:58,300 --> 00:06:55,100
the rainbow and the wavelength that

167
00:07:00,340 --> 00:06:58,310
we're looking at so our first point to

168
00:07:04,240 --> 00:07:00,350
examine here with one of the tracklist

169
00:07:05,980 --> 00:07:04,250
cases is that polarizing features have

170
00:07:07,780 --> 00:07:05,990
distinct shapes and of course their

171
00:07:08,800 --> 00:07:07,790
dominance varies with wavelength as you

172
00:07:10,660 --> 00:07:08,810
might expect the Rayleigh scattering

173
00:07:13,060 --> 00:07:10,670
will be very strong if you're looking at

174
00:07:14,830 --> 00:07:13,070
blue wavelengths and if you can start

175
00:07:17,200 --> 00:07:14,840
moving towards redder wavelengths if you

176
00:07:18,940 --> 00:07:17,210
had a planet that had ocean glint that

177
00:07:21,700 --> 00:07:18,950
would be a strong polarizing feature and

178
00:07:24,850 --> 00:07:21,710
that would start to pop out as you look

179
00:07:28,360 --> 00:07:24,860
towards redder and redder wavelengths if

180
00:07:30,490 --> 00:07:28,370
we have a planet that has a cloud

181
00:07:32,260 --> 00:07:30,500
present we get these a very distinct

182
00:07:35,230 --> 00:07:32,270
rainbow features these are very clear

183
00:07:38,500 --> 00:07:35,240
features to see in polarized light the

184
00:07:39,670 --> 00:07:38,510
strength of the rainbow compared to the

185
00:07:42,220 --> 00:07:39,680
other features like the Rayleigh

186
00:07:45,730 --> 00:07:42,230
scattering will depend on the cloud

187
00:07:47,560 --> 00:07:45,740
height if you're very interested in how

188
00:07:48,940 --> 00:07:47,570

to determine your cloud height and kind

189
00:07:50,770 --> 00:07:48,950
of disentangle that from molecular

190
00:07:53,920 --> 00:07:50,780
abundances I would highly recommend

191
00:07:58,990 --> 00:07:53,930
looking at the paper from Thomas Boucher

192
00:08:00,460 --> 00:07:59,000
Oh tomorrow she I'm sorry from 2017 it's

193
00:08:06,700 --> 00:08:00,470
a really brilliant paper but I can't get

194
00:08:08,740 --> 00:08:06,710
into that right now right and so even in

195
00:08:11,590 --> 00:08:08,750
cases like this where we have an

196
00:08:13,780 --> 00:08:11,600
atmosphere that is maybe very strongly

197
00:08:17,350 --> 00:08:13,790
really scattering and we're masking that

198
00:08:19,750 --> 00:08:17,360
a weaker rainbow signal from a different

199
00:08:23,050 --> 00:08:19,760
species in the cloud if we're moving

200
00:08:25,510 --> 00:08:23,060
towards red wavelengths we're starting

201
00:08:28,030 --> 00:08:25,520
to be able to pick out the difference in

202
00:08:33,130 --> 00:08:28,040
those curves the one that has the cloud

203
00:08:34,540 --> 00:08:33,140
present the one that does not so

204
00:08:36,100 --> 00:08:34,550
different scenarios of cloudy

205
00:08:38,110 --> 00:08:36,110
atmospheres do you seem to be

206
00:08:40,480 --> 00:08:38,120
distinguishable just looking at these

207
00:08:43,870 --> 00:08:40,490
different Trappist archetypes you can

208
00:08:45,310 --> 00:08:43,880
tell them apart from one another and of

209
00:08:48,460 --> 00:08:45,320
course they're going to change in

210
00:08:51,550 --> 00:08:48,470
wavelength in particular and predictable

211
00:08:52,150 --> 00:08:51,560
ways so this is suggesting that this

212
00:08:54,280 --> 00:08:52,160
might be

213
00:08:56,590 --> 00:08:54,290

useful technique to tell different kind

214
00:09:00,790 --> 00:08:56,600
of basic anticipated planet archetypes

215
00:09:02,199 --> 00:09:00,800
apart and I should point out that I'm

216
00:09:04,499 --> 00:09:02,209
kind of simplifying things here I'm

217
00:09:06,699 --> 00:09:04,509
showing you the total polarization in

218
00:09:08,170 --> 00:09:06,709
reality we're normally looking at Stokes

219
00:09:10,780 --> 00:09:08,180
parameters we have a little bit more

220
00:09:12,280 --> 00:09:10,790
information than the last few plots that

221
00:09:14,110 --> 00:09:12,290
I've shown you so we're looking at

222
00:09:15,970 --> 00:09:14,120
Stokes Q and U and we're getting

223
00:09:18,689 --> 00:09:15,980
positive and negative values that also

224
00:09:22,379 --> 00:09:18,699
behave in particular ways depending on

225
00:09:24,519 --> 00:09:22,389
your rainbow behavior and your

226
00:09:27,879 --> 00:09:24,529
scattering surface if you're looking at

227
00:09:30,340 --> 00:09:27,889
a surface if the values on the y-axis

228
00:09:33,280 --> 00:09:30,350
have been wearing you after I told you

229
00:09:35,619 --> 00:09:33,290
we can currently detect on to around one

230
00:09:37,689 --> 00:09:35,629
part per million you might consider

231
00:09:43,240 --> 00:09:37,699
looking at sub Neptune's mini Neptune's

232
00:09:45,220 --> 00:09:43,250
so GJ 1214b depending on its cub specie

233
00:09:47,800 --> 00:09:45,230
is dominant in the upper atmosphere and

234
00:09:50,559 --> 00:09:47,810
the size of the particles can produce

235
00:09:53,100 --> 00:09:50,569
optical effects that would be near

236
00:09:56,710 --> 00:09:53,110
current detection limits with

237
00:09:58,720 --> 00:09:56,720
contemporary polarimeters so we're

238
00:10:02,850 --> 00:09:58,730

getting very close to that one part per

239
00:10:10,120 --> 00:10:07,800
so with a part per million precision

240
00:10:12,460 --> 00:10:10,130
polarimeter which is what we currently

241
00:10:14,550 --> 00:10:12,470
have and several hours of observation

242
00:10:18,490 --> 00:10:14,560
which is pretty typical of an aperture

243
00:10:19,900 --> 00:10:18,500
polarimeter observing these days if we

244
00:10:21,699 --> 00:10:19,910
were looking for one of these one

245
00:10:25,269 --> 00:10:21,709
designed part per million signals from a

246
00:10:27,340 --> 00:10:25,279
planet we could do that currently just

247
00:10:28,870 --> 00:10:27,350
with what we have right now with a

248
00:10:30,490 --> 00:10:28,880
4-metre class telescopes if we're

249
00:10:32,620 --> 00:10:30,500
looking at a star like HD one eight nine

250
00:10:35,230 --> 00:10:32,630
if we're looking at a star like Proxima

251
00:10:37,689 --> 00:10:35,240
Sun and our band we would want to use an

252
00:10:39,429 --> 00:10:37,699
eight meter telescope Proxima Sun and B

253
00:10:41,530 --> 00:10:39,439
band if we want to get some comparison

254
00:10:43,299 --> 00:10:41,540
in the different wavelengths and start

255
00:10:45,819 --> 00:10:43,309
to tell these features more clearly

256
00:10:48,009 --> 00:10:45,829
apart we would need to use a thirty

257
00:10:50,319 --> 00:10:48,019
meter telescope so basically right now

258
00:10:53,619 --> 00:10:50,329
if there was a hot mini Neptune in

259
00:10:55,389 --> 00:10:53,629
Proximus then or something larger and

260
00:10:57,100 --> 00:10:55,399
hotter than that we should be able to

261
00:11:01,299 --> 00:10:57,110
detect it or almost be able to detect it

262
00:11:03,970 --> 00:11:01,309
with a dedicated program if we wanted to

263
00:11:05,710 --> 00:11:03,980

observe a dimmer star of course we just

264
00:11:07,809 --> 00:11:05,720
need to stare longer use them even

265
00:11:10,179 --> 00:11:07,819
bigger telescope if we want to be

266
00:11:11,980 --> 00:11:10,189
looking for planets in polarized light

267
00:11:14,410 --> 00:11:11,990
that are in the habitable zone this

268
00:11:16,269 --> 00:11:14,420
would improve or this would require that

269
00:11:19,840 --> 00:11:16,279
we improve our polarimeter design to

270
00:11:22,629 --> 00:11:19,850
some degree so I tend to kind of

271
00:11:25,110 --> 00:11:22,639
summarize polarimetry by saying that

272
00:11:28,360 --> 00:11:25,120
although the nature of polarimetry

273
00:11:31,179 --> 00:11:28,370
reduces the throughput of your photons

274
00:11:33,429 --> 00:11:31,189
it improves contrast and certainty so we

275
00:11:35,170 --> 00:11:33,439
really need to be thinking about the

276
00:11:38,050 --> 00:11:35,180
scenarios in which this is a useful

277
00:11:39,490 --> 00:11:38,060
technique and whether or not we want to

278
00:11:40,990 --> 00:11:39,500
be building our telescopes and our

279
00:11:42,639 --> 00:11:41,000
instruments for this sort of thing and

280
00:11:44,590 --> 00:11:42,649
if so what particular things we want to

281
00:11:45,970 --> 00:11:44,600
be looking for because it is certainly

282
00:11:47,499 --> 00:11:45,980
useful in some cases particularly

283
00:11:51,119 --> 00:11:47,509
dealing with clouds and things that are

284
00:11:53,740 --> 00:11:51,129
not transiting we need to continue to

285
00:11:55,210 --> 00:11:53,750
characterize noise particularly from

286
00:11:57,730 --> 00:11:55,220
stellar activity and cool stars

287
00:12:00,790 --> 00:11:57,740
especially if we want to keep looking at

288
00:12:03,160 --> 00:12:00,800

M dwarfs to overcome issues with food

289
00:12:06,040 --> 00:12:03,170
put to some degree we can use things

290
00:12:07,540 --> 00:12:06,050
like dedicated stairs and thoughtful

291
00:12:09,009 --> 00:12:07,550
observations being a little more

292
00:12:10,660 --> 00:12:09,019
particular than maybe we've been in the

293
00:12:14,139 --> 00:12:10,670
past about which planets we're looking

294
00:12:16,329 --> 00:12:14,149
at and to overcome noise we can consider

295
00:12:18,790 --> 00:12:16,339
things like simultaneous observations

296
00:12:20,439 --> 00:12:18,800
that will help us characterize things

297
00:12:22,269 --> 00:12:20,449
like stellar activity to help us

298
00:12:24,100 --> 00:12:22,279
characterize that noise and also

299
00:12:26,379 --> 00:12:24,110
improving technology which sounds like a

300
00:12:28,869 --> 00:12:26,389
you know kind of ask a really easy thing

301
00:12:31,150 --> 00:12:28,879
to say an hard thing to do but I just

302
00:12:32,889 --> 00:12:31,160
want to point out that hippy the most

303
00:12:34,929 --> 00:12:32,899
sensitive polarimeter in the world right

304
00:12:37,980 --> 00:12:34,939
now for visible wavelengths is built

305
00:12:40,600 --> 00:12:37,990
from the 3d printed components and

306
00:12:43,749 --> 00:12:40,610
optical and lab materials that you can

307
00:12:46,210 --> 00:12:43,759
get out of a lab catalog is a very

308
00:12:48,639 --> 00:12:46,220
inexpensive it's very reproducible and

309
00:12:54,429 --> 00:12:48,649
there are great ideas out there about

310
00:12:56,949 --> 00:12:54,439
how to improve the the noise the the

311
00:12:59,549 --> 00:12:56,959
throughput and the abilities of

312
00:13:01,869 --> 00:12:59,559
polarimeters that people have but

313
00:13:05,079 --> 00:13:01,879

couldn't maybe be funded I don't have a

314
00:13:07,569 --> 00:13:05,089
particular it is just to be clear so I

315
00:13:11,110 --> 00:13:07,579
just want to end on this note of

316
00:13:12,759 --> 00:13:11,120
pointing out that many upcoming space

317
00:13:15,669 --> 00:13:12,769
telescopes and ground-based telescopes

318
00:13:18,550 --> 00:13:15,679
have or considering having or definitely

319
00:13:25,689 --> 00:13:18,560
planning to have polarimeters we

320
00:13:28,600 --> 00:13:25,699
voir origins Space Telescope the TMT the

321
00:13:30,850 --> 00:13:28,610
e-elt w first all have plans for

322
00:13:32,350 --> 00:13:30,860
polarimeters or considering fans for

323
00:13:37,179 --> 00:13:32,360
polarimeters we need to think really

324
00:13:39,759 --> 00:13:37,189
hard over what wavelengths those

325
00:13:41,559 --> 00:13:39,769
polarimeters will cover for example

326
00:13:45,340 --> 00:13:41,569
leVoir will only be in the UV and

327
00:13:46,629 --> 00:13:45,350
origins would Chris be in infrared and

328
00:13:48,160 --> 00:13:46,639
the kind of science that we would be

329
00:13:50,079 --> 00:13:48,170
able to do with that we also need to

330
00:13:52,840 --> 00:13:50,089
think about architecture and whether

331
00:13:55,720 --> 00:13:52,850
it's useful for the kind of science that

332
00:13:58,540 --> 00:13:55,730
we want to do for us to have our

333
00:14:00,910 --> 00:13:58,550
polarimeters in front of our own master

334
00:14:02,920 --> 00:14:00,920
after them because that's going to also

335
00:14:05,590 --> 00:14:02,930
determine obviously the type of science

336
00:14:16,720 --> 00:14:05,600
that we could be doing and without all

337
00:14:21,210 --> 00:14:16,730
open it to questions yes so are you

338
00:14:23,559 --> 00:14:21,220

assuming like it covers the entire

339
00:14:26,350 --> 00:14:23,569
planet like a disk integrated right so

340
00:14:30,429 --> 00:14:26,360
then you're really combining yeah yeah

341
00:14:34,960 --> 00:14:30,439
so so these are disk integrated the

342
00:14:36,790 --> 00:14:34,970
signals for planets that have a uniform

343
00:14:38,170 --> 00:14:36,800
coverage of whatever it is that I've

344
00:14:39,670 --> 00:14:38,180
done there so they can have a different

345
00:14:41,740 --> 00:14:39,680
grounds and a different you know

346
00:14:44,829 --> 00:14:41,750
different layers of clouds but it's over

347
00:14:47,139 --> 00:14:44,839
the entire planet the output from these

348
00:14:50,619 --> 00:14:47,149
star which is modeling code that I use

349
00:14:54,639 --> 00:14:50,629
actually does produce a pretty outfit so

350
00:14:56,079 --> 00:14:54,649
it's in the works I guess I don't know

351
00:14:58,900 --> 00:14:56,089
how fast it'll come up but it's in the

352
00:15:05,490 --> 00:14:58,910
works to be able to produce or be able

353
00:15:07,869 --> 00:15:05,500
to use a 3d input to like improve the

354
00:15:19,030 --> 00:15:07,879
swath of things that we could be

355
00:15:22,110 --> 00:15:19,040
exploring with B star yeah RJ hi RJ from

356
00:15:24,280 --> 00:15:22,120
Oxford at the beginning you mentioned

357
00:15:25,419 --> 00:15:24,290
chiral molecules and then you said you

358
00:15:28,480 --> 00:15:25,429
were going to talk about it anymore but

359
00:15:30,730 --> 00:15:28,490
I wanted to ask if so do chiral

360
00:15:32,200 --> 00:15:30,740
molecules produce like a noticeable

361
00:15:36,550 --> 00:15:32,210
polar

362
00:15:41,920 --> 00:15:36,560
signal in mmm spectroscopy yeah so

363
00:15:45,100 --> 00:15:41,930

chiral molecules can impart circularly

364
00:15:48,220 --> 00:15:45,110
polarized light that's really too weak

365
00:15:51,699 --> 00:15:48,230
of a signal for anytime in the near

366
00:15:53,980 --> 00:15:51,709
future to be doing that with exoplanets

367
00:15:56,380 --> 00:15:53,990
most likely but it's something that's

368
00:15:58,120 --> 00:15:56,390
really useful and interesting for

369
00:16:00,250 --> 00:15:58,130
astrobiology studies in our own solar

370
00:16:02,019 --> 00:16:00,260
system you could potentially be doing

371
00:16:22,810 --> 00:16:02,029
this just with like a Europa Lander or

372
00:16:24,699 --> 00:16:22,820
something like that yes that was a

373
00:16:27,460 --> 00:16:24,709
really interesting talk Ted camasta q

374
00:16:30,130 --> 00:16:27,470
Chicago so it seemed like you needed

375
00:16:31,750 --> 00:16:30,140
like phase resolved observations to get

376
00:16:33,010 --> 00:16:31,760
information about say like clouds or

377
00:16:35,230 --> 00:16:33,020
something in the atmosphere do you

378
00:16:36,790 --> 00:16:35,240
always need like a full half orbit phase

379
00:16:38,110 --> 00:16:36,800
curve or is there like shorter term

380
00:16:41,590 --> 00:16:38,120
observations that can tell you something

381
00:16:42,940 --> 00:16:41,600
similar you could if you have some idea

382
00:16:44,650 --> 00:16:42,950
of what you want to look for or what you

383
00:16:46,510 --> 00:16:44,660
could anticipate from a planet which I

384
00:16:48,220 --> 00:16:46,520
mean you can just sometimes do from

385
00:16:50,920 --> 00:16:48,230
physics knowing the size of it and what

386
00:16:54,579 --> 00:16:50,930
sort of you know Cubs you might expect

387
00:16:57,130 --> 00:16:54,589
where you can just kind of sample around

388
00:16:58,720 --> 00:16:57,140

where you might expect say a rainbow and

389
00:17:01,120 --> 00:16:58,730
see if you do see the peak in the

390
00:17:02,290 --> 00:17:01,130
rainbow exactly where you predict if you

391
00:17:04,540 --> 00:17:02,300
think that there's water clouds at the

392
00:17:06,880 --> 00:17:04,550
top of the atmosphere does that arise at

393
00:17:10,540 --> 00:17:06,890
the right spot for the cloud height that

394
00:17:11,980 --> 00:17:10,550
you expect you can you can really narrow

395
00:17:16,329 --> 00:17:11,990
this down so you can just do a lot of

396
00:17:17,290 --> 00:17:16,339
sampling at a particular point if that's

397
00:17:19,829 --> 00:17:17,300
something that you're looking for if

398
00:17:21,880 --> 00:17:19,839
you're trying to do something like

399
00:17:23,140 --> 00:17:21,890
constraint orbital parameters or

400
00:17:25,090 --> 00:17:23,150
something like that that's depending a

401
00:17:26,199 --> 00:17:25,100
lot more on like the general shape up

402
00:17:32,919 --> 00:17:26,209
the curves and you would want really

403
00:17:33,330 --> 00:17:32,929
good sampling throughout if there are no

404
00:17:35,340 --> 00:17:33,340
additional

405
00:17:35,880 --> 00:17:35,350
questions thank Kim