
AbSciCon
2017
MESA, ARIZONA

1
00:00:06,160 --> 00:00:13,950
you

2
00:00:18,190 --> 00:00:16,570
so my name is Alex pixel I'm a graduate

3
00:00:20,589 --> 00:00:18,200
student at the University of Arizona

4
00:00:22,630 --> 00:00:20,599
I work in Daniel up high in his and

5
00:00:24,940 --> 00:00:22,640
other solar system work that's a project

6
00:00:27,910 --> 00:00:24,950
funded by NASA exoplanet Nexus program

7
00:00:31,290 --> 00:00:27,920
and today I'm going to be talking about

8
00:00:34,510 --> 00:00:31,300
the bulk properties of Proxima Centuri

9
00:00:36,430 --> 00:00:34,520
so some background and the month since

10
00:00:38,590 --> 00:00:36,440
the discovery we've seen a lot of really

11
00:00:40,930 --> 00:00:38,600
in depth and really insightful work done

12
00:00:43,360 --> 00:00:40,940
to treat this planet's atmosphere and

13
00:00:45,569 --> 00:00:43,370

potential habitability orbital evolution

14
00:00:48,670 --> 00:00:45,579
and even as we've seen the

15
00:00:49,660 --> 00:00:48,680
prospects for a characterization in the

16
00:00:51,280 --> 00:00:49,670
near future and I'm sure we're going to

17
00:00:53,110 --> 00:00:51,290
hear a lot more about that today but

18
00:00:54,910 --> 00:00:53,120
what I want to talk about and it's a lot

19
00:00:56,310 --> 00:00:54,920
along the slides of what Steven Kage's

20
00:00:58,990 --> 00:00:56,320
talked about is

21
00:01:00,850 --> 00:00:59,000
what underlying assumptions do we have

22
00:01:02,799 --> 00:01:00,860
here about the planets bulk properties

23
00:01:03,999 --> 00:01:02,809
in particular I want to know what can we

24
00:01:06,279 --> 00:01:04,009
observe and what can we not

25
00:01:08,170 --> 00:01:06,289
observational II constrain so we can

26
00:01:10,090 --> 00:01:08,180
observe stellar properties and many of

27
00:01:12,370 --> 00:01:10,100
the orbital properties but we don't know

28
00:01:14,830 --> 00:01:12,380
the inclination and so as we've heard

29
00:01:16,539 --> 00:01:14,840
when you measure an RV signal you're

30
00:01:19,600 --> 00:01:16,549
only given the mass projected along

31
00:01:21,760 --> 00:01:19,610
basically your line of sight what we

32
00:01:23,560 --> 00:01:21,770
cannot directly observe is a rocky or

33
00:01:25,270 --> 00:01:23,570
terrestrial composition we can't

34
00:01:26,500 --> 00:01:25,280
directly determine what the mass is and

35
00:01:28,810 --> 00:01:26,510
we really don't have much of a

36
00:01:31,060 --> 00:01:28,820
constraint observational e on what the

37
00:01:32,560 --> 00:01:31,070
radius might be I'm particularly

38
00:01:35,440 --> 00:01:32,570

concerned about the composition here

39
00:01:37,330 --> 00:01:35,450
there's been a growing consensus of sort

40
00:01:39,820 --> 00:01:37,340
of bimodal distribution from one to four

41
00:01:41,289 --> 00:01:39,830
Earth radii where you have of course

42
00:01:43,630 --> 00:01:41,299
planets like the earth small radius

43
00:01:46,380 --> 00:01:43,640
higher density but also larger planets

44
00:01:48,280 --> 00:01:46,390
with higher volatile on ice fractions

45
00:01:52,090 --> 00:01:48,290
similar in composition to but not

46
00:01:53,200 --> 00:01:52,100
necessarily as large as Neptune and of

47
00:01:55,030 --> 00:01:53,210
course that would have serious

48
00:01:56,170 --> 00:01:55,040
implications for the habitability which

49
00:01:57,120 --> 00:01:56,180
brings effect to the scene of this

50
00:01:59,920 --> 00:01:57,130
session

51
00:02:01,450 --> 00:01:59,930
so my general method is to place the

52
00:02:03,280 --> 00:02:01,460
observational constraints that we do

53
00:02:05,859 --> 00:02:03,290
have into a Bayesian framework where I

54
00:02:08,380 --> 00:02:05,869
substitute the non directly observable

55
00:02:10,539 --> 00:02:08,390
parameters with statistical priors based

56
00:02:12,310 --> 00:02:10,549
on previous work from planets for which

57
00:02:14,020 --> 00:02:12,320
for example we have combined transit and

58
00:02:18,350 --> 00:02:14,030
RD mass measurements for TGV mass

59
00:02:23,630 --> 00:02:21,320
it there we go occurrence rates from

60
00:02:27,020 --> 00:02:23,640
Kepler for the radius mass radius

61
00:02:28,880 --> 00:02:27,030
relationship to determine the mass we

62
00:02:30,020 --> 00:02:28,890
don't really have any observational

63
00:02:31,820 --> 00:02:30,030

constraints on the inclination I've

64
00:02:34,070 --> 00:02:31,830
assumed an isotropic distribution and

65
00:02:36,950 --> 00:02:34,080
then we have composition as a function

66
00:02:40,400 --> 00:02:36,960
of radius so I reference a pretty highly

67
00:02:42,860 --> 00:02:40,410
cited work by Leslie Rogers in 2015 who

68
00:02:44,180 --> 00:02:42,870
found that above about 1.6 or 3-day you

69
00:02:47,290 --> 00:02:44,190
see a sharp drop-off in the number of

70
00:02:49,990 --> 00:02:47,300
planets which are dense enough to be

71
00:02:52,190 --> 00:02:50,000
explained by a rocky composition

72
00:02:53,390 --> 00:02:52,200
so we feed all these priors in the

73
00:02:55,540 --> 00:02:53,400
observables into a Monte Carlo

74
00:02:58,190 --> 00:02:55,550
simulation from which we can extract

75
00:02:59,630 --> 00:02:58,200
posterior constraints on the mass the

76
00:03:01,510 --> 00:02:59,640
radius and the composition which are not

77
00:03:03,920 --> 00:03:01,520
directly observable

78
00:03:06,440 --> 00:03:03,930
so all directorates into the right panel

79
00:03:07,820 --> 00:03:06,450
here this represents a posterior mass

80
00:03:10,880 --> 00:03:07,830
distribution for the actual mass

81
00:03:12,650 --> 00:03:10,890
approximate Cindy I decomposed it into a

82
00:03:14,270 --> 00:03:12,660
blue shaded region representing a rocky

83
00:03:16,610 --> 00:03:14,280
population in the red shaded region

84
00:03:18,050 --> 00:03:16,620
representing a I call it a sub Neptune

85
00:03:19,970 --> 00:03:18,060
population but basically with a large

86
00:03:21,800 --> 00:03:19,980
volatile component or perhaps ice

87
00:03:23,479 --> 00:03:21,810
fraction and of course we see that the

88
00:03:25,340 --> 00:03:23,489

Iraqi population dominates the posterior

89
00:03:26,949 --> 00:03:25,350
mass distribution as we should expect

90
00:03:29,210 --> 00:03:26,959
for special Mass Planet

91
00:03:31,580 --> 00:03:29,220
we can extract from our parts terior

92
00:03:33,680 --> 00:03:31,590
distributions expectation values and to

93
00:03:34,660 --> 00:03:33,690
Sigma confidence intervals for the mass

94
00:03:36,710 --> 00:03:34,670
and radius

95
00:03:38,449 --> 00:03:36,720
briefly what I'll note here is of course

96
00:03:40,910 --> 00:03:38,459
the expectation value for the mass is a

97
00:03:44,240 --> 00:03:40,920
bit higher than the proposed measured a

98
00:03:46,370 --> 00:03:44,250
so-called minimum mass of which we would

99
00:03:48,199 --> 00:03:46,380
expect and also that the radius as I

100
00:03:49,550 --> 00:03:48,209
mentioned is not even with these

101
00:03:51,380 --> 00:03:49,560
constraints taken into place is not

102
00:03:52,729 --> 00:03:51,390
particularly well constrained but I

103
00:03:53,710 --> 00:03:52,739
thought that these values might be of

104
00:03:56,150 --> 00:03:53,720
use to

105
00:03:57,530 --> 00:03:56,160
in particular modelers who are trying to

106
00:03:59,570 --> 00:03:57,540
understand the interior composition of

107
00:04:01,190 --> 00:03:59,580
this planet we asked the question is the

108
00:04:03,949 --> 00:04:01,200
planet rocky we find that in our

109
00:04:05,720 --> 00:04:03,959
posterior distributions about 90% of the

110
00:04:07,820 --> 00:04:05,730
cases the planet does have a rocky

111
00:04:10,580 --> 00:04:07,830
composition bearing in mind that based

112
00:04:12,199 --> 00:04:10,590
on the scheme were using this work by

113
00:04:14,840 --> 00:04:12,209

Leslie Rogers in 2015 doesn't

114
00:04:17,449 --> 00:04:14,850
necessarily exclude very low radius

115
00:04:19,310 --> 00:04:17,459
population of volatile rich components

116
00:04:21,650 --> 00:04:19,320
so I put that as an upper bound but I

117
00:04:23,540 --> 00:04:21,660
imagine it's pretty close so these are

118
00:04:26,880 --> 00:04:23,550
the work this Buser results I published

119
00:04:28,650 --> 00:04:26,890
in February but what I'd like to do is

120
00:04:30,240 --> 00:04:28,660
expand upon this work for the more

121
00:04:32,940 --> 00:04:30,250
recent result from the California Kepler

122
00:04:36,330 --> 00:04:32,950
survey so we've seen a paper on the

123
00:04:38,460 --> 00:04:36,340
archive as of March I think which finds

124
00:04:40,710 --> 00:04:38,470
evidence for a dual peak distribution in

125
00:04:43,560 --> 00:04:40,720
the occurrence rates centered around

126
00:04:45,120 --> 00:04:43,570
about 1.75 Earth radii so this very

127
00:04:47,250 --> 00:04:45,130
straightforwardly lends itself to the

128
00:04:49,650 --> 00:04:47,260
interpretation that I've been discussing

129
00:04:51,120 --> 00:04:49,660
which is that we have a low radius more

130
00:04:53,970 --> 00:04:51,130
rocky population in a higher radius

131
00:04:55,800 --> 00:04:53,980
volatile population in fact if you were

132
00:04:58,710 --> 00:04:55,810
here on Tuesday there is a talk by Owen

133
00:05:01,710 --> 00:04:58,720
labour who presented a hydrogen manacle

134
00:05:03,480 --> 00:05:01,720
model a formulation which predicted that

135
00:05:06,000 --> 00:05:03,490
plaintiffs below 1.7 or three-day would

136
00:05:08,070 --> 00:05:06,010
lose volatile atmospheres very early on

137
00:05:09,720 --> 00:05:08,080
in the life Channel to start so this is

138
00:05:12,630 --> 00:05:09,730

highly consistent with that if we just

139
00:05:15,540 --> 00:05:12,640
take this as a hard boundary at 1.75 we

140
00:05:17,040 --> 00:05:15,550
had somewhat higher kin estimates for

141
00:05:18,390 --> 00:05:17,050
the expectation values for its mass and

142
00:05:20,040 --> 00:05:18,400
radius and I think a much better

143
00:05:22,110 --> 00:05:20,050
constraint on the probability that it's

144
00:05:24,720 --> 00:05:22,120
actually a rocky planet as originally

145
00:05:28,370 --> 00:05:24,730
proposed in the discovery paper that's

146
00:05:31,500 --> 00:05:28,380
about 95 percent so I'll discuss the

147
00:05:32,820 --> 00:05:31,510
significance of these results so for

148
00:05:34,230 --> 00:05:32,830
this target in particular I think we can

149
00:05:36,420 --> 00:05:34,240
all agree this is one of the most

150
00:05:38,820 --> 00:05:36,430
interesting targets we have I've

151
00:05:40,409 --> 00:05:38,830
provided more robust constraints on the

152
00:05:42,030 --> 00:05:40,419
mass radius and Composition the more

153
00:05:45,090 --> 00:05:42,040
originally available following discovery

154
00:05:48,840 --> 00:05:45,100
in particular I've calculated that it's

155
00:05:50,810 --> 00:05:48,850
about 95 percent likely that this planet

156
00:05:53,360 --> 00:05:50,820
does in fact have a composition

157
00:05:56,190 --> 00:05:53,370
comparable to that of the earth of

158
00:05:58,200 --> 00:05:56,200
then there's that one in 20 case and I

159
00:06:00,420 --> 00:05:58,210
think that becomes that it could

160
00:06:01,860 --> 00:06:00,430
actually have a volatile component I

161
00:06:04,320 --> 00:06:01,870
think that becomes important when you

162
00:06:06,330 --> 00:06:04,330
start expanding if we are able to push

163
00:06:09,420 --> 00:06:06,340

down our V sensitivity and find more and

164
00:06:13,700 --> 00:06:09,430
more small sized exoplanets in the

165
00:06:18,090 --> 00:06:16,530
what I have here is a plot of the chance

166
00:06:20,040 --> 00:06:18,100
that this planet is going to be rocky as

167
00:06:21,780 --> 00:06:20,050
a function of the measured in times of

168
00:06:23,540 --> 00:06:21,790
sine the inclination assuming all the

169
00:06:25,680 --> 00:06:23,550
other parameters stay about the same and

170
00:06:27,540 --> 00:06:25,690
what we see of course is that it falls

171
00:06:29,100 --> 00:06:27,550
off with increasing maps but also that

172
00:06:30,659 --> 00:06:29,110
it seems to be highly sensitive to where

173
00:06:33,600 --> 00:06:30,669
we draw this cutoff in our planet

174
00:06:35,550 --> 00:06:33,610
populations in your current rates to

175
00:06:38,310 --> 00:06:35,560
which radius does this transition

176
00:06:42,880 --> 00:06:41,080
so yeah in particularly basically this I

177
00:06:45,340 --> 00:06:42,890
want to know what I want to know is what

178
00:06:47,080 --> 00:06:45,350
are the underlying populations here what

179
00:06:48,820 --> 00:06:47,090
do these constituent populations look

180
00:06:50,980 --> 00:06:48,830
like in a function of occurrence versus

181
00:06:53,350 --> 00:06:50,990
radius it turns out if you have some

182
00:06:55,540 --> 00:06:53,360
pollution of the sub Neptune population

183
00:06:57,430 --> 00:06:55,550
to lower radii maybe 0.1 0.2 it doesn't

184
00:06:58,720 --> 00:06:57,440
significantly impact the results we

185
00:07:00,190 --> 00:06:58,730
could imagine that there's a very long

186
00:07:02,590 --> 00:07:00,200
tail here that which could extend all

187
00:07:04,240 --> 00:07:02,600
the way down to about north radius and

188
00:07:05,890 --> 00:07:04,250

could significantly increase the

189
00:07:07,960 --> 00:07:05,900
likelihood that we have the sub neptune

190
00:07:09,450 --> 00:07:07,970
masquerading as a 1.3 earth-mass planet

191
00:07:11,710 --> 00:07:09,460
I

192
00:07:12,730 --> 00:07:11,720
also think it's important to understand

193
00:07:14,560 --> 00:07:12,740
the spread in the mass radius

194
00:07:17,260 --> 00:07:14,570
relationship I borrowed this figure from

195
00:07:19,000 --> 00:07:17,270
the Weiss and Marci paper in 2014 but I

196
00:07:20,440 --> 00:07:19,010
can also provide an anecdote so in the

197
00:07:23,080 --> 00:07:20,450
past four weeks we discovered a rocky

198
00:07:25,060 --> 00:07:23,090
planet with a density all the 12 to 13

199
00:07:27,910 --> 00:07:25,070
grams per cubic centimeter around the M

200
00:07:31,330 --> 00:07:27,920
star in the habitable zone of LHS 1140 B

201
00:07:33,970 --> 00:07:31,340
we have also had seen updated masses for

202
00:07:35,830 --> 00:07:33,980
the Trappist one planets which assigns

203
00:07:38,230 --> 00:07:35,840
them densities which are consistent with

204
00:07:40,420 --> 00:07:38,240
a very significant water fraction 50

205
00:07:42,490 --> 00:07:40,430
percentile under person and so these are

206
00:07:43,930 --> 00:07:42,500
very similar systems and that they're

207
00:07:45,760 --> 00:07:43,940
both in stars they're both receiving

208
00:07:47,980 --> 00:07:45,770
about the same amount of insulation and

209
00:07:49,240 --> 00:07:47,990
yet we have such a large spread what

210
00:07:51,520 --> 00:07:49,250
these compositions can be and that

211
00:07:52,840 --> 00:07:51,530
provides us a lot of uncertainty and

212
00:07:54,540 --> 00:07:52,850
what the radius is if we can't measure

213
00:07:56,770 --> 00:07:54,550

it directly

214
00:07:58,810 --> 00:07:56,780
in general I think that we could apply

215
00:08:01,390 --> 00:07:58,820
this method to say directly imaged

216
00:08:03,670 --> 00:08:01,400
exoplanets if you know what planet this

217
00:08:05,440 --> 00:08:03,680
is you know it's not a rocky planet but

218
00:08:07,870 --> 00:08:05,450
we could imagine that we had seen

219
00:08:10,240 --> 00:08:07,880
something like this and we only have an

220
00:08:11,530 --> 00:08:10,250
idea of what the luminosity is that's a

221
00:08:13,420 --> 00:08:11,540
function of the radius as well as the

222
00:08:15,190 --> 00:08:13,430
albedo in the solar system even among

223
00:08:17,800 --> 00:08:15,200
solar system rocky planets albedo is

224
00:08:19,300 --> 00:08:17,810
highly unconstrained and so if we could

225
00:08:21,760 --> 00:08:19,310
get some sort of modeling prior

226
00:08:24,190 --> 00:08:21,770
constraints on what the albedo of a

227
00:08:26,380 --> 00:08:24,200
rocky planet is or volatile which planet

228
00:08:28,270 --> 00:08:26,390
is or colors photometric colors as well

229
00:08:29,710 --> 00:08:28,280
that can bind to the spectra would give

230
00:08:31,570 --> 00:08:29,720
us a much better idea of what kinds of

231
00:08:34,270 --> 00:08:31,580
targets targets were actually looking at

232
00:08:37,080 --> 00:08:34,280
with missions like Oh James goad would

233
00:08:40,659 --> 00:08:37,090
mainly have X blue bar

234
00:08:43,060 --> 00:08:40,669
so in conclusion I provided two sigma or

235
00:08:45,240 --> 00:08:43,070
95% confidence interval constraints on

236
00:08:47,920 --> 00:08:45,250
the mass and radius of this planet

237
00:08:49,730 --> 00:08:47,930
I've also provided an estimate of just

238
00:08:51,680 --> 00:08:49,740

how likely it is at this point in fact

239
00:08:53,420 --> 00:08:51,690
rocky and I think it's fairly high but

240
00:08:54,890 --> 00:08:53,430
of course because there's such a high

241
00:08:57,800 --> 00:08:54,900
mass tale and a potential for low mass

242
00:08:59,750 --> 00:08:57,810
vault average planets it's not one I

243
00:09:02,210 --> 00:08:59,760
think we need to do further work in

244
00:09:03,820 --> 00:09:02,220
particular to understand the underlying

245
00:09:06,620 --> 00:09:03,830
distribution of

246
00:09:09,920 --> 00:09:06,630
sub Neptune's versus rocky sized planets

247
00:09:11,360 --> 00:09:09,930
in radius space and to understand what

248
00:09:13,160 --> 00:09:11,370
causes the spread of the mass radius

249
00:09:16,400 --> 00:09:13,170
relationship can we control for factors

250
00:09:17,990 --> 00:09:16,410
such as stellar type or luminosity and

251
00:09:19,330 --> 00:09:18,000
finally I would generally encourage a

252
00:09:23,990 --> 00:09:19,340
more

253
00:09:26,870 --> 00:09:24,000
large-scale statistical approach to

254
00:09:28,730 --> 00:09:26,880
interpreting our results when we have

255
00:09:31,130 --> 00:09:28,740
planets with unobservable parameters

256
00:09:37,990 --> 00:09:31,140
namely our V detected indirectly image

257
00:09:43,660 --> 00:09:40,880
all right thank you Alex I so yes we

258
00:09:45,680 --> 00:09:43,670
have plenty time for questions okay

259
00:09:47,330 --> 00:09:45,690
Washington

260
00:09:49,100 --> 00:09:47,340
I love the talk I love your last

261
00:09:51,110 --> 00:09:49,110
sentence I'm a big fan of Bayesian

262
00:09:53,750 --> 00:09:51,120
statistics I just want to echo what I

263
00:09:55,640 --> 00:09:53,760

said earlier that in the case when we

264
00:09:57,200 --> 00:09:55,650
don't have data like for this planet

265
00:09:59,090 --> 00:09:57,210
like we don't know what it's true mass

266
00:10:01,550 --> 00:09:59,100
is and we have very little directly

267
00:10:03,710 --> 00:10:01,560
observed properties we want to use as

268
00:10:05,240 --> 00:10:03,720
many of the priors that we have

269
00:10:08,450 --> 00:10:05,250
available as possible and so it'd be

270
00:10:09,980 --> 00:10:08,460
awesome if we did combine the geometric

271
00:10:13,760 --> 00:10:09,990
probability with the studies that you

272
00:10:16,790 --> 00:10:13,770
showed up mass radius relations with the

273
00:10:19,160 --> 00:10:16,800
information that M dwarfs don't have

274
00:10:21,680 --> 00:10:19,170
giant planets look at actual the

275
00:10:23,000 --> 00:10:21,690
actually the distribution of planet

276
00:10:24,410 --> 00:10:23,010
population as a function of stellar mass

277
00:10:26,180 --> 00:10:24,420
and incorporate that into a Bayesian

278
00:10:27,590 --> 00:10:26,190
framework I imagine this would give you

279
00:10:29,680 --> 00:10:27,600
even stronger constraints on the

280
00:10:32,090 --> 00:10:29,690
probability that it's rocky oh

281
00:10:34,520 --> 00:10:32,100
right so these are the occurrence rates

282
00:10:36,980 --> 00:10:34,530
that you use for reference and right I

283
00:10:38,510 --> 00:10:36,990
haven't really thought specifically in

284
00:10:39,620 --> 00:10:38,520
terms of what populations appear around

285
00:10:41,540 --> 00:10:39,630
endorsing I think that would be

286
00:10:44,510 --> 00:10:41,550
important but I do at least try to

287
00:10:46,370 --> 00:10:44,520
constrain the occurrence rates of radii

288
00:10:48,520 --> 00:10:46,380

that's awesome I must have missed it

289
00:10:52,869 --> 00:10:48,530
slightly ya know it could be that some

290
00:10:57,519 --> 00:10:55,059
this graph and it's about one to one but

291
00:10:59,199 --> 00:10:57,529
this is not for any stars right right so

292
00:11:03,689 --> 00:10:59,209
of course that's something important to

293
00:11:09,340 --> 00:11:07,109
any more questions

294
00:11:10,270 --> 00:11:09,350
all right well if not let's thank Alex