
AbSciCon
2017
MESA, ARIZONA

1
00:00:00,220 --> 00:00:12,470
[Music]

2
00:00:21,810 --> 00:00:16,019
hi it's great to be here some fantastic

3
00:00:23,040 --> 00:00:21,820
talks in this session probably not going

4
00:00:25,409 --> 00:00:23,050
to answer this question by the end of

5
00:00:30,630 --> 00:00:25,419
the talk but let's see I'll keep you in

6
00:00:33,600 --> 00:00:30,640
suspense until halfway through so this

7
00:00:36,329 --> 00:00:33,610
is a figure from a paper the Roy Barnes

8
00:00:39,000 --> 00:00:36,339
and I wrote a few years ago now where we

9
00:00:41,250 --> 00:00:39,010
looked at the fact that M dwarfs take a

10
00:00:43,170 --> 00:00:41,260
really long time to contract fully

11
00:00:45,420 --> 00:00:43,180
during the pre main sequence phase and

12
00:00:46,439 --> 00:00:45,430
how that can negatively affect planets

13
00:00:50,549 --> 00:00:46,449

in the habitable zone because they

14
00:00:52,350 --> 00:00:50,559
experience actual total flux is much

15
00:00:54,149 --> 00:00:52,360
larger than the runaway greenhouse limit

16
00:00:56,579 --> 00:00:54,159
for up to hundreds of millions of years

17
00:00:58,740 --> 00:00:56,589
especially around low-mass M dwarfs such

18
00:01:00,570 --> 00:00:58,750
as Proxima Centauri and so what that

19
00:01:02,429 --> 00:01:00,580
means is that you're in a runaway

20
00:01:03,899 --> 00:01:02,439
greenhouse assuming you have an ocean of

21
00:01:06,570 --> 00:01:03,909
water on your surface you're in a

22
00:01:08,070 --> 00:01:06,580
runaway greenhouse for several hundred

23
00:01:11,070 --> 00:01:08,080
million years during which time water

24
00:01:12,840 --> 00:01:11,080
can escape to space and oxygen can build

25
00:01:15,450 --> 00:01:12,850
up via the heavier oxygen atoms are

26
00:01:18,330 --> 00:01:15,460
preferentially held back in the

27
00:01:21,120 --> 00:01:18,340
atmosphere and so this is a figure from

28
00:01:24,480 --> 00:01:21,130
our paper where we show the amount of

29
00:01:26,160 --> 00:01:24,490
water lost in terrestrial oceans as a

30
00:01:27,510 --> 00:01:26,170
function of stellar mass and solar

31
00:01:30,270 --> 00:01:27,520
masses and position in the habitable

32
00:01:31,440 --> 00:01:30,280
zone so this is the recent Venus early

33
00:01:33,960 --> 00:01:31,450
Mars limits and then the more

34
00:01:36,450 --> 00:01:33,970
conservative habitable zone bounded by

35
00:01:40,190 --> 00:01:36,460
these white lines and so you can see

36
00:01:42,450 --> 00:01:40,200
that for a planet such as Proxima be

37
00:01:44,130 --> 00:01:42,460
roughly in this position in the relative

38
00:01:46,230 --> 00:01:44,140

position the habitable zone around a

39
00:01:48,480 --> 00:01:46,240
star about one point point one two solar

40
00:01:50,940 --> 00:01:48,490
masses you'd expect it to lose lots of

41
00:01:52,340 --> 00:01:50,950
oceans based on this mechanism and you

42
00:01:54,330 --> 00:01:52,350
might also expect that to build up

43
00:01:56,730 --> 00:01:54,340
something like on the order of a

44
00:01:58,020 --> 00:01:56,740
thousand bars of oxygen in its

45
00:01:59,510 --> 00:01:58,030
atmosphere and obviously not all of that

46
00:02:02,160 --> 00:01:59,520
stays in the atmosphere it can get

47
00:02:03,990 --> 00:02:02,170
reacted away with other components in

48
00:02:07,050 --> 00:02:04,000
the atmosphere or reacted away at the

49
00:02:08,369 --> 00:02:07,060
surface since oxygen is so reactive but

50
00:02:10,020 --> 00:02:08,379
we can do better than this obviously

51
00:02:11,940 --> 00:02:10,030
this was a figure four five earth-mass

52
00:02:13,740 --> 00:02:11,950
planet and these escape rates change a

53
00:02:15,809 --> 00:02:13,750
lot and it also depends on the details

54
00:02:17,759 --> 00:02:15,819
of the x-ray flux for the star so we can

55
00:02:20,209 --> 00:02:17,769
do a little better than this

56
00:02:22,530 --> 00:02:20,219
and what I'm showing here is the

57
00:02:25,330 --> 00:02:22,540
essentially the framework for what we

58
00:02:27,890 --> 00:02:25,340
call V planet which is Rory Barnes

59
00:02:29,330 --> 00:02:27,900
planet evolution simulator whose

60
00:02:30,800 --> 00:02:29,340
ultimate goal is to try to address

61
00:02:35,060 --> 00:02:30,810
whether or not any given planet might be

62
00:02:37,250 --> 00:02:35,070
habitable by coupling processes ranging

63
00:02:38,960 --> 00:02:37,260

from thermal evolution of a planet's

64
00:02:41,300 --> 00:02:38,970
cord atmospheric escape to stellar

65
00:02:43,430 --> 00:02:41,310
evolution and even galactic evolution as

66
00:02:46,160 --> 00:02:43,440
we'll hear from a few talks later today

67
00:02:47,900 --> 00:02:46,170
and so for the specific case of

68
00:02:50,810 --> 00:02:47,910
atmospheric escape and how it affects

69
00:02:53,270 --> 00:02:50,820
the water content of the planet what we

70
00:02:54,800 --> 00:02:53,280
have as input our basic properties of

71
00:02:57,170 --> 00:02:54,810
the planet such as its mass radius

72
00:03:00,710 --> 00:02:57,180
semi-major axis some initial properties

73
00:03:02,000 --> 00:03:00,720
so as Tony hinted earlier the amount of

74
00:03:04,220 --> 00:03:02,010
hydrogen that the planet forms might

75
00:03:05,750 --> 00:03:04,230
matter because the hydrogen will escape

76
00:03:07,130 --> 00:03:05,760
first because it's scale height is much

77
00:03:09,230 --> 00:03:07,140
larger that's that's what's going to

78
00:03:10,790 --> 00:03:09,240
drive the hydrodynamic wind early on and

79
00:03:12,140 --> 00:03:10,800
so if you have a substantial amount of

80
00:03:13,640 --> 00:03:12,150
hydrogen that could actually protect

81
00:03:16,820 --> 00:03:13,650
your volatile content closer to the

82
00:03:18,260 --> 00:03:16,830
surface obviously you need to input what

83
00:03:20,990 --> 00:03:18,270
you believe the initial water content to

84
00:03:23,060 --> 00:03:21,000
the planet to be when it formed and then

85
00:03:24,949 --> 00:03:23,070
you put everything into this little

86
00:03:27,020 --> 00:03:24,959
black box called V planet with some

87
00:03:28,580 --> 00:03:27,030
parametrizations for the evolution of

88
00:03:30,199 --> 00:03:28,590

luminosity of the star the evolution of

89
00:03:33,530 --> 00:03:30,209
the x-ray and extreme ultraviolet

90
00:03:35,300 --> 00:03:33,540
luminosity the star you model the escape

91
00:03:39,259 --> 00:03:35,310
efficiency with in a hydrodynamic

92
00:03:41,150 --> 00:03:39,269
parameter ization and some details about

93
00:03:43,570 --> 00:03:41,160
where you put the oxygen that's being

94
00:03:45,860 --> 00:03:43,580
formed you crunch all the numbers and

95
00:03:47,150 --> 00:03:45,870
you get your answer and you ultimately

96
00:03:50,300 --> 00:03:47,160
answer where the planets habitable or

97
00:03:51,979 --> 00:03:50,310
not so let's do that the planet as we

98
00:03:54,590 --> 00:03:51,989
saw the minimum mass is one point two

99
00:03:57,979 --> 00:03:54,600
seven earth masses its radius is one

100
00:03:59,630 --> 00:03:57,989
point O seven bear with me the

101
00:04:03,740 --> 00:03:59,640
semi-major axis from the discovery paper

102
00:04:05,570 --> 00:04:03,750
is 0.049 you can look at some population

103
00:04:07,160 --> 00:04:05,580
synthesis models and come up with some

104
00:04:10,070 --> 00:04:07,170
plausible amount of hydrogen that it

105
00:04:14,509 --> 00:04:10,080
formed with some plausible amount of

106
00:04:16,509 --> 00:04:14,519
water that it formed with you can look

107
00:04:19,099 --> 00:04:16,519
at some stellar evolution tracks for the

108
00:04:20,870 --> 00:04:19,109
observed metallicity of the star and the

109
00:04:25,219 --> 00:04:20,880
observed mass and some mixing length

110
00:04:27,230 --> 00:04:25,229
parameter that you hand-wave and same

111
00:04:27,560 --> 00:04:27,240
thing for the XUV luminosity we observe

112
00:04:32,090 --> 00:04:27,570
it

113
00:04:35,060 --> 00:04:32,100

following a power law from based on this

114
00:04:36,409 --> 00:04:35,070
study and several others you can run a

115
00:04:37,670 --> 00:04:36,419
hydrodynamic code to get the escape

116
00:04:38,390 --> 00:04:37,680
efficiency which is the fraction of

117
00:04:45,469 --> 00:04:38,400
energy

118
00:04:47,180 --> 00:04:45,479
converted to escape and some Permenter

119
00:04:50,710 --> 00:04:47,190
ization for the oxygen absorption such

120
00:04:54,590 --> 00:04:50,720
as Laura Schaeffer did for GJ 1130 to be

121
00:04:56,300 --> 00:04:54,600
where we actually we're still working on

122
00:04:58,010 --> 00:04:56,310
this but where we actually calculate the

123
00:04:59,570 --> 00:04:58,020
rate of which oxygen is absorbed into

124
00:05:02,450 --> 00:04:59,580
them into the mag motion on the surface

125
00:05:04,580 --> 00:05:02,460
and so you put this onto V planet and

126
00:05:06,710 --> 00:05:04,590
you get the answer that you know in this

127
00:05:08,629 --> 00:05:06,720
specific case you get sixty bars of

128
00:05:10,460 --> 00:05:08,639
oxygen remaining the atmosphere no

129
00:05:13,070 --> 00:05:10,470
hydrogen no water the planet is not

130
00:05:17,510 --> 00:05:13,080
habitable thank you I'm just kidding I'm

131
00:05:20,480 --> 00:05:17,520
just kidding this is a terrible way to

132
00:05:23,270 --> 00:05:20,490
answer this question so it's not like a

133
00:05:24,890 --> 00:05:23,280
closure slide and now I will reveal to

134
00:05:26,120 --> 00:05:24,900
you that I'm not actually going to

135
00:05:28,040 --> 00:05:26,130
answer this question because we don't

136
00:05:29,570 --> 00:05:28,050
yet have enough information so the point

137
00:05:31,040 --> 00:05:29,580
of this talk I was actually a little

138
00:05:32,930 --> 00:05:31,050

scared when I had saw Alex big holes

139
00:05:34,670 --> 00:05:32,940
pockets like he's giving my talk the

140
00:05:36,350 --> 00:05:34,680
point of my talk is to just convince you

141
00:05:37,969 --> 00:05:36,360
that Bayesian statistics is what we need

142
00:05:40,100 --> 00:05:37,979
to do to answer these kinds of questions

143
00:05:42,440 --> 00:05:40,110
we need to be very rigorous very robust

144
00:05:44,270 --> 00:05:42,450
about treating probability treating

145
00:05:46,339 --> 00:05:44,280
uncertainties making sure that we're

146
00:05:48,200 --> 00:05:46,349
accounting for all prior information so

147
00:05:50,270 --> 00:05:48,210
that we can actually get a robust answer

148
00:05:51,560 --> 00:05:50,280
to the question pointing to a planet and

149
00:05:53,570 --> 00:05:51,570
say it's habitable or it's not habitable

150
00:05:54,710 --> 00:05:53,580
is we're not there yet they're not going

151
00:05:55,909 --> 00:05:54,720
to be there for a very long time we're

152
00:05:57,980 --> 00:05:55,919
going to be able to hopefully assign

153
00:06:01,879 --> 00:05:57,990
probabilities with very large error bars

154
00:06:03,529 --> 00:06:01,889
and so let's walk through that we can't

155
00:06:04,969 --> 00:06:03,539
really say any of these things with that

156
00:06:06,500 --> 00:06:04,979
much confidence in fact there are error

157
00:06:08,990 --> 00:06:06,510
bars associated with all of these

158
00:06:10,760 --> 00:06:09,000
numbers and buried in all of these

159
00:06:13,250 --> 00:06:10,770
models right each one of these models

160
00:06:15,350 --> 00:06:13,260
here assumes several other parameters

161
00:06:16,640 --> 00:06:15,360
and if you just go to a study and you

162
00:06:18,830 --> 00:06:16,650
know I get their maximum likelihood

163
00:06:20,540 --> 00:06:18,840

estimate for what you know I don't know

164
00:06:22,909 --> 00:06:20,550
the hydrodynamic escape efficiency is

165
00:06:24,290 --> 00:06:22,919
for a certain planet you are sweeping

166
00:06:26,210 --> 00:06:24,300
under the rug a lot of uncertainty so

167
00:06:30,920 --> 00:06:26,220
you need to propagate it along in your

168
00:06:32,870 --> 00:06:30,930
models correctly and so my the first

169
00:06:35,390 --> 00:06:32,880
takeaway is that uncertainty isn't

170
00:06:37,370 --> 00:06:35,400
matter and so we saw several talks

171
00:06:39,589 --> 00:06:37,380
earlier that you can't just say that

172
00:06:42,439 --> 00:06:39,599
Proxima has 1.27 or masses that is the

173
00:06:43,730 --> 00:06:42,449
minimum mass geometrically it could have

174
00:06:45,290 --> 00:06:43,740
much larger mass and be on a larger

175
00:06:47,180 --> 00:06:45,300
inclination and there's also an

176
00:06:49,580 --> 00:06:47,190
uncertainty on the minimum mass itself

177
00:06:50,999 --> 00:06:49,590
from the noise and the RV data so you

178
00:06:55,559 --> 00:06:51,009
actually get a distribution like you

179
00:06:57,629 --> 00:06:55,569
from a couple talks earlier where I mean

180
00:07:00,109 --> 00:06:57,639
it's the the probable mass is close to

181
00:07:02,639 --> 00:07:00,119
that but this is really a distribution

182
00:07:04,499 --> 00:07:02,649
same for the semi-major axis alright

183
00:07:06,659 --> 00:07:04,509
what you get from are V of the period

184
00:07:08,700 --> 00:07:06,669
there's a large uncertainty to convert

185
00:07:09,959 --> 00:07:08,710
that to a semi-major axis you need to

186
00:07:11,939 --> 00:07:09,969
account for the mass of the star which

187
00:07:13,649 --> 00:07:11,949
there's a large uncertainty there and so

188
00:07:16,079 --> 00:07:13,659

you get a distribution there as well so

189
00:07:18,629 --> 00:07:16,089
in certainties matter data matters I

190
00:07:20,159 --> 00:07:18,639
can't just use a luminosity of Aleutian

191
00:07:21,959 --> 00:07:20,169
track to compute the luminosity of a

192
00:07:24,119 --> 00:07:21,969
star if it doesn't match the present-day

193
00:07:27,079 --> 00:07:24,129
luminosity and so you need a robust way

194
00:07:29,610 --> 00:07:27,089
of accounting for that now m-dwarf

195
00:07:33,209 --> 00:07:29,620
isochrones are notoriously bad because

196
00:07:35,969 --> 00:07:33,219
as a Suzanne Holly always says there

197
00:07:37,529 --> 00:07:35,979
does not exist a typical M dwarf all M

198
00:07:38,879 --> 00:07:37,539
dwarfs are different they're not all

199
00:07:41,369 --> 00:07:38,889
going to follow the same track there's a

200
00:07:44,129 --> 00:07:41,379
very large spread especially at low M

201
00:07:49,230 --> 00:07:44,139
dwarf masses and so you need to somehow

202
00:07:51,719 --> 00:07:49,240
account for I mean the best handle you

203
00:07:53,129 --> 00:07:51,729
have on this is the observed data right

204
00:07:55,019 --> 00:07:53,139
which is the luminosity to start today

205
00:07:56,929 --> 00:07:55,029
and I need to news the track the back

206
00:07:58,709 --> 00:07:56,939
track what it was in the past

207
00:08:00,480 --> 00:07:58,719
conditioned on the fact that you know

208
00:08:04,260 --> 00:08:00,490
what it is today and the same for the

209
00:08:05,999 --> 00:08:04,270
XUV luminosity and then finally and this

210
00:08:09,269 --> 00:08:06,009
is the most important one

211
00:08:12,839 --> 00:08:09,279
priors matter right I can't just assume

212
00:08:14,850 --> 00:08:12,849
a certain initial volatile and venturi

213
00:08:16,649 --> 00:08:14,860

inventory I need to look at population

214
00:08:19,549 --> 00:08:16,659
synthesis models and so we need to do

215
00:08:22,409 --> 00:08:19,559
things like look at formation rates and

216
00:08:24,449 --> 00:08:22,419
you know how quickly planets accumulate

217
00:08:25,889 --> 00:08:24,459
gas from the disk in order to get

218
00:08:27,059 --> 00:08:25,899
initial hydrogen fraction which matters

219
00:08:30,059 --> 00:08:27,069
a lot for the amount of water that

220
00:08:32,639 --> 00:08:30,069
finally escapes from the planet and the

221
00:08:35,040 --> 00:08:32,649
same for oceans so we need to figure out

222
00:08:36,180 --> 00:08:35,050
this is this is as you'll see this is

223
00:08:37,620 --> 00:08:36,190
the principal thing that we need to

224
00:08:39,180 --> 00:08:37,630
figure out is how many oceans these

225
00:08:40,649 --> 00:08:39,190
planets are forming with because I

226
00:08:42,480 --> 00:08:40,659
cannot tell you whether this planet is

227
00:08:45,150 --> 00:08:42,490
habitable today or not if we don't know

228
00:08:48,240 --> 00:08:45,160
how much it formed with and so priors

229
00:08:50,490 --> 00:08:48,250
matter and so we need to move away

230
00:08:52,650 --> 00:08:50,500
especially you know if we're going to

231
00:08:53,970 --> 00:08:52,660
try to figure out what the planets are

232
00:08:55,860 --> 00:08:53,980
habitable we need to move away from this

233
00:08:57,480 --> 00:08:55,870
maximum likelihood approach and take a

234
00:09:00,420 --> 00:08:57,490
more Bayesian approach where we

235
00:09:02,250 --> 00:09:00,430
transform these priors these data these

236
00:09:03,660 --> 00:09:02,260
uncertainties into a posterior

237
00:09:04,150 --> 00:09:03,670
distribution for how much water there is

238
00:09:07,150 --> 00:09:04,160

on a spot

239
00:09:09,940 --> 00:09:07,160
today and the way we do that so this is

240
00:09:11,770 --> 00:09:09,950
work in preparation is we have some

241
00:09:13,990 --> 00:09:11,780
input vector where we have all our

242
00:09:16,690 --> 00:09:14,000
priors and our data the mass of the star

243
00:09:18,910 --> 00:09:16,700
some parametrizations of the XUV

244
00:09:21,100 --> 00:09:18,920
saturation time and the power law that

245
00:09:23,200 --> 00:09:21,110
describes the XUV evolution some

246
00:09:25,570 --> 00:09:23,210
properties of the planet and the initial

247
00:09:27,760 --> 00:09:25,580
volatile content you have your model

248
00:09:30,100 --> 00:09:27,770
outputs right you feed this into the

249
00:09:31,630 --> 00:09:30,110
planet and you get this out luminosity

250
00:09:33,340 --> 00:09:31,640
to start today the XUV luminosity to

251
00:09:37,630 --> 00:09:33,350
start today and more importantly the

252
00:09:38,950 --> 00:09:37,640
amount of water today and the way the

253
00:09:40,870 --> 00:09:38,960
way you treat this in a Bayesian sense

254
00:09:43,390 --> 00:09:40,880
is you assign some likelihood function

255
00:09:45,310 --> 00:09:43,400
right you want your model output to

256
00:09:47,350 --> 00:09:45,320
match the present-day stellar luminosity

257
00:09:48,490 --> 00:09:47,360
and the same with the XUV luminosity you

258
00:09:51,670 --> 00:09:48,500
want to fold in all your prior

259
00:09:53,470 --> 00:09:51,680
information there and there's no

260
00:09:55,420 --> 00:09:53,480
analytic way to convert this into a

261
00:09:56,710 --> 00:09:55,430
posterior distribution for water so you

262
00:09:59,020 --> 00:09:56,720
need to run something like a Markov

263
00:10:01,360 --> 00:09:59,030

chain Monte Carlo simulation where you

264
00:10:02,890 --> 00:10:01,370
use this likelihood and run a long chain

265
00:10:04,980 --> 00:10:02,900
of simulations to get an actual

266
00:10:06,730 --> 00:10:04,990
posterior and so we started doing this

267
00:10:09,670 --> 00:10:06,740
what I'm presenting here is very

268
00:10:12,370 --> 00:10:09,680
preliminary results but these are

269
00:10:14,890 --> 00:10:12,380
posterior samples as an example for the

270
00:10:17,380 --> 00:10:14,900
stellar evolution and so the red line is

271
00:10:18,790 --> 00:10:17,390
the mean of all our samples and each of

272
00:10:22,330 --> 00:10:18,800
the black lines are just randomly drawn

273
00:10:23,920 --> 00:10:22,340
from our MC MC posteriors this dashed

274
00:10:25,750 --> 00:10:23,930
line is the observed value for each of

275
00:10:28,030 --> 00:10:25,760
these quantities the stellar luminosity

276
00:10:31,570 --> 00:10:28,040
XUV luminosity and Celer radius and you

277
00:10:32,860 --> 00:10:31,580
can see that on average they match the

278
00:10:34,630 --> 00:10:32,870
present-day value but there is a very

279
00:10:37,870 --> 00:10:34,640
large spread after you account for all

280
00:10:39,070 --> 00:10:37,880
your uncertainties and at the end of the

281
00:10:40,660 --> 00:10:39,080
day you might get something like this

282
00:10:42,670 --> 00:10:40,670
and again there's a big asterisk here

283
00:10:44,890 --> 00:10:42,680
this has not been marginalized over

284
00:10:46,930 --> 00:10:44,900
population synthesis outputs

285
00:10:49,300 --> 00:10:46,940
I have no robustly accounted for oxygen

286
00:10:50,500 --> 00:10:49,310
sinks and so this is just an example but

287
00:10:52,240 --> 00:10:50,510
at the end of the day you'll get

288
00:10:53,500 --> 00:10:52,250

something like this it's a marginalized

289
00:10:55,840 --> 00:10:53,510
posterior distribution for the water

290
00:10:58,270 --> 00:10:55,850
content today with a large peak close to

291
00:11:00,520 --> 00:10:58,280
zero but a long tail and these are very

292
00:11:02,440 --> 00:11:00,530
non gaps right I can't quote this as two

293
00:11:04,900 --> 00:11:02,450
plus or minus three it's it's a

294
00:11:06,940 --> 00:11:04,910
complicated distribution and the same

295
00:11:08,800 --> 00:11:06,950
for oxygen and we can start to see them

296
00:11:10,660 --> 00:11:08,810
as Tony was saying like in a lot of

297
00:11:12,670 --> 00:11:10,670
cases no matter what you assume the

298
00:11:14,740 --> 00:11:12,680
planet does lose a lot of water but

299
00:11:17,320 --> 00:11:14,750
there is a broad and non-negligible tail

300
00:11:19,030 --> 00:11:17,330
where the planet maintains oceans today

301
00:11:20,620 --> 00:11:19,040
and another thing that's interesting I

302
00:11:22,360 --> 00:11:20,630
know I'm running out of time here so

303
00:11:23,230 --> 00:11:22,370
I'll do this quickly another thing

304
00:11:24,970 --> 00:11:23,240
that's interesting to look at

305
00:11:27,009 --> 00:11:24,980
correlations between parameters which is

306
00:11:28,600 --> 00:11:27,019
what MCMC allows you to do and you can

307
00:11:30,220 --> 00:11:28,610
see that oxygen and water very tightly

308
00:11:32,170 --> 00:11:30,230
correlated the more water you lose the

309
00:11:33,340 --> 00:11:32,180
more oxygen you build up what this

310
00:11:35,860 --> 00:11:33,350
correlation eventually breaks down

311
00:11:37,300 --> 00:11:35,870
because oxygen escape or water escape is

312
00:11:38,920 --> 00:11:37,310
self-limiting once you start building up

313
00:11:41,230 --> 00:11:38,930

a lot of oxygen the hydrogen needs to

314
00:11:43,480 --> 00:11:41,240
diffuse up through the oxygen and it

315
00:11:45,819 --> 00:11:43,490
throttles the escape rate and so that

316
00:11:49,000 --> 00:11:45,829
correlation breaks down you can look at

317
00:11:50,380 --> 00:11:49,010
these posterior joint posteriors for all

318
00:11:52,240 --> 00:11:50,390
your parameters in your model and you

319
00:11:54,519 --> 00:11:52,250
can stare at this for a couple hours and

320
00:11:55,980 --> 00:11:54,529
you know put this on a t-shirt I think

321
00:12:01,960 --> 00:11:55,990
it's really pretty

322
00:12:03,430 --> 00:12:01,970
but maybe I'll do that so the strongest

323
00:12:06,460 --> 00:12:03,440
correlations here and this is my last

324
00:12:09,190 --> 00:12:06,470
point obviously the water and oxygen but

325
00:12:11,079 --> 00:12:09,200
also the saturation fraction the XUV

326
00:12:12,730 --> 00:12:11,089
saturation fraction and the amount of

327
00:12:16,930 --> 00:12:12,740
water to build up now the xeb saturation

328
00:12:18,610 --> 00:12:16,940
fraction is the ratio of the stellar XUV

329
00:12:21,639 --> 00:12:18,620
luminosity to the stellar bulla metric

330
00:12:24,100 --> 00:12:21,649
luminosity early on when the star is

331
00:12:26,500 --> 00:12:24,110
young and for M dwarfs that is somewhere

332
00:12:28,240 --> 00:12:26,510
around 10 to the minus 3 so 10 to the

333
00:12:29,800 --> 00:12:28,250
minus 3 of the star's light is emitted

334
00:12:32,019 --> 00:12:29,810
in the XUV early on because it's very

335
00:12:33,310 --> 00:12:32,029
active but it's not very well

336
00:12:35,110 --> 00:12:33,320
constrained there's a very large spread

337
00:12:37,120 --> 00:12:35,120
and we can see that our model is

338
00:12:38,860 --> 00:12:37,130

extremely sensitive to that the higher

339
00:12:40,300 --> 00:12:38,870
that value the more water you lose and

340
00:12:42,730 --> 00:12:40,310
so before we actually until we actually

341
00:12:43,720 --> 00:12:42,740
pinpoint that exact value for Proxima

342
00:12:45,970 --> 00:12:43,730
Centauri which may or may not be

343
00:12:47,889 --> 00:12:45,980
possible we're not going to be

344
00:12:48,850 --> 00:12:47,899
completely sure about our answers and

345
00:12:51,730 --> 00:12:48,860
we're going to get a large distribution

346
00:12:53,199 --> 00:12:51,740
for the water content so as I said

347
00:12:57,100 --> 00:12:53,209
before I did not answer the question I

348
00:12:59,620 --> 00:12:57,110
never intended to because this is an

349
00:13:01,030 --> 00:12:59,630
incremental iterative problem that we're

350
00:13:02,439 --> 00:13:01,040
going to have to do this iteratively

351
00:13:04,120 --> 00:13:02,449
right like right now we have certain

352
00:13:06,360 --> 00:13:04,130
data certain prior certain uncertainties

353
00:13:08,319 --> 00:13:06,370
we can come up with these large

354
00:13:09,760 --> 00:13:08,329
long-tailed probability distributions

355
00:13:13,990 --> 00:13:09,770
for water but they're going to get

356
00:13:15,460 --> 00:13:14,000
narrower narrower as as data comes in

357
00:13:18,550 --> 00:13:15,470
and hopefully that will that will be

358
00:13:22,060 --> 00:13:18,560
soon it so we can certainly look at this

359
00:13:24,970 --> 00:13:22,070
with a glass-half-full attitude which

360
00:13:26,710 --> 00:13:24,980
which I'm which absolutely we showed

361
00:13:27,970 --> 00:13:26,720
because this is the closest potentially

362
00:13:29,340 --> 00:13:27,980
habitable planet and should it be

363
00:13:30,960 --> 00:13:29,350

excited about it

364
00:13:38,970 --> 00:13:30,970
so I'll leave it at that I'll take

365
00:13:39,990 --> 00:13:38,980
questions Thank You Rodrigo we have to

366
00:13:45,210 --> 00:13:40,000
have about one or two questions so

367
00:13:48,900 --> 00:13:45,220
please thanks Ari very nice talk Evgenia

368
00:13:51,480 --> 00:13:48,910
Skolnick ASU so of all the observables

369
00:13:52,200 --> 00:13:51,490
what is the most important one that you

370
00:13:55,800 --> 00:13:52,210
need to know

371
00:13:58,040 --> 00:13:55,810
did I hear XUV yeah heard actually that

372
00:14:00,450 --> 00:13:58,050
was my question before you said it

373
00:14:02,220 --> 00:14:00,460
okay so in that case I will advertise

374
00:14:03,720 --> 00:14:02,230
for Adam Schneider's talk this afternoon

375
00:14:05,580 --> 00:14:03,730
that we'll be able to answer that for

376
00:14:07,170 --> 00:14:05,590
you for the practice would be spectral

377
00:14:10,860 --> 00:14:07,180
type awesome thank you I look forward to

378
00:14:12,900 --> 00:14:10,870
it great job I think this is definitely

379
00:14:15,270 --> 00:14:12,910
the right approach so here's the mean

380
00:14:16,980 --> 00:14:15,280
question how do you account for missing

381
00:14:18,990 --> 00:14:16,990
model physics you know there's all sorts

382
00:14:21,780 --> 00:14:19,000
of physics we're not accounting for two

383
00:14:24,360 --> 00:14:21,790
1d model yeah it just shows you know two

384
00:14:26,610 --> 00:14:24,370
compositions water and hydrogen so how

385
00:14:28,490 --> 00:14:26,620
do you to channel the inner Fortney here

386
00:14:33,270 --> 00:14:28,500
how do you handle the unknown unknown

387
00:14:35,220 --> 00:14:33,280
the short answer I have no idea right I

388
00:14:36,420 --> 00:14:35,230

mean yeah I mean we're trying to answer

389
00:14:37,980 --> 00:14:36,430
a very difficult question ultimately

390
00:14:39,450 --> 00:14:37,990
it's not about how much water is on

391
00:14:41,070 --> 00:14:39,460
there but if it's planet habitable and

392
00:14:43,770 --> 00:14:41,080
is it inhabited and there's tons of

393
00:14:45,900 --> 00:14:43,780
physics there we don't understand - so I

394
00:14:48,210 --> 00:14:45,910
think this is a start but absolutely

395
00:14:50,010 --> 00:14:48,220
like we depend like it's going to depend

396
00:14:52,170 --> 00:14:50,020
a lot on further modeling for their

397
00:14:54,240 --> 00:14:52,180
atmospheric modeling to actually map out

398
00:14:56,040 --> 00:14:54,250
all the possibilities so that we can

399
00:14:59,070 --> 00:14:56,050
properly account for them this is just

400
00:15:01,470 --> 00:14:59,080
what we currently know and gonna have to

401
00:15:03,030 --> 00:15:01,480
build on that unfortunately we're going

402
00:15:04,380 --> 00:15:03,040
to have to move on so I'm sorry for that

403
00:15:06,000 --> 00:15:04,390
but if you talk to whoever you hopefully