
AbSciCon
2017
MESA, ARIZONA

1
00:00:00,220 --> 00:00:12,440
[Music]

2
00:00:18,269 --> 00:00:15,990
all right I'm Russell Dietrich I'm a

3
00:00:20,249 --> 00:00:18,279
student at University of Washington also

4
00:00:22,140 --> 00:00:20,259
working with the VPL I'm going to be

5
00:00:25,769 --> 00:00:22,150
shifting gears a little bit and talking

6
00:00:29,640 --> 00:00:25,779
about larger scale processes in

7
00:00:34,829 --> 00:00:29,650
particular the triple star system of

8
00:00:36,750 --> 00:00:34,839
alpha cen and Proxima so in case you

9
00:00:39,229 --> 00:00:36,760
haven't heard a planet was discovered

10
00:00:46,200 --> 00:00:39,239
orbiting Proxima Centauri our nearest

11
00:00:48,899 --> 00:00:46,210
neighbor alright alright I'll move on so

12
00:00:51,270 --> 00:00:48,909
one of the things that Tom Quinn who's a

13
00:00:54,420 --> 00:00:51,280

professor at u-dub pointed out right

14
00:00:56,369 --> 00:00:54,430
away was that Proxima is not alone in

15
00:00:59,969 --> 00:00:56,379
this image we can see Alpha Centauri a

16
00:01:02,700 --> 00:00:59,979
and B a little Proxima is circled in

17
00:01:06,480 --> 00:01:02,710
that with that red circle there it's

18
00:01:10,740 --> 00:01:06,490
barely visible in this image Proxima is

19
00:01:13,469 --> 00:01:10,750
about 13,000 au from Alpha Centauri a

20
00:01:15,030 --> 00:01:13,479
and B for a long time it was unsure

21
00:01:17,220 --> 00:01:15,040
whether it was gravitationally bound or

22
00:01:18,990 --> 00:01:17,230
not although new evidence strongly

23
00:01:22,500 --> 00:01:19,000
suggests that it is gravitationally

24
00:01:24,480 --> 00:01:22,510
bound we wanted to work from the

25
00:01:26,910 --> 00:01:24,490
assumption that it is gravitationally

26
00:01:30,810 --> 00:01:26,920
bound to Alpha Centauri a and B and if

27
00:01:32,940 --> 00:01:30,820
we assume that then we one of the things

28
00:01:34,440 --> 00:01:32,950
that we have to consider is that the

29
00:01:38,700 --> 00:01:34,450
Galactic environment actually affects

30
00:01:40,740 --> 00:01:38,710
its orbit so in particular this can

31
00:01:43,740 --> 00:01:40,750
cause close encounters close approaches

32
00:01:45,950 --> 00:01:43,750
between Alpha Centauri and Proxima and

33
00:01:48,750 --> 00:01:45,960
we wanted to see how this might be

34
00:01:52,290 --> 00:01:48,760
effect be able to affect its planetary

35
00:01:56,160 --> 00:01:52,300
system this was inspired by a study a

36
00:01:58,500 --> 00:01:56,170
few years back by cabañal and they

37
00:02:01,110 --> 00:01:58,510
basically took the solar system gas

38
00:02:03,270 --> 00:02:01,120

giants and the Sun and placed it in a

39
00:02:04,890 --> 00:02:03,280
wide binary system and one of the things

40
00:02:07,200 --> 00:02:04,900
that they found is that they these

41
00:02:09,839 --> 00:02:07,210
galactic forces that I haven't explained

42
00:02:12,240 --> 00:02:09,849
yet but will in a moment they actually

43
00:02:16,589 --> 00:02:12,250
drive the system to high eccentricity in

44
00:02:19,530 --> 00:02:16,599
many cases and cause a disruption of the

45
00:02:22,470 --> 00:02:19,540
outer planets which of course is a

46
00:02:23,570 --> 00:02:22,480
catastrophic if you if you are concerned

47
00:02:29,600 --> 00:02:23,580
about your planets or

48
00:02:30,830 --> 00:02:29,610
system maintaining nice stable orbits so

49
00:02:35,330 --> 00:02:30,840
the Galactic forces that I'm referring

50
00:02:38,780 --> 00:02:35,340
to are to two items the Galactic tides

51
00:02:41,630 --> 00:02:38,790
and stellar encounters what I mean by

52
00:02:44,960 --> 00:02:41,640
that is stars that pass within a parsec

53
00:02:47,180 --> 00:02:44,970
or so of the system galactic tides are

54
00:02:49,280 --> 00:02:47,190
basically just this idea that it is

55
00:02:52,100 --> 00:02:49,290
denser close to the galactic mid plane

56
00:02:53,840 --> 00:02:52,110
and so at a given moment the two stars

57
00:02:55,970 --> 00:02:53,850
may be different distances from the

58
00:02:59,090 --> 00:02:55,980
Galactic mid plane and be experiencing

59
00:03:00,710 --> 00:02:59,100
different gravitational forces and so we

60
00:03:03,230 --> 00:03:00,720
can think of that as a tide a

61
00:03:06,710 --> 00:03:03,240
differential force across the system the

62
00:03:10,460 --> 00:03:06,720
other is forces from passing stars which

63
00:03:13,060 --> 00:03:10,470

can ski in part or steal a little energy

64
00:03:15,260 --> 00:03:13,070
or angular momentum from the system

65
00:03:17,540 --> 00:03:15,270
another thing that I'm going to kind of

66
00:03:20,240 --> 00:03:17,550
gloss over here but I'm happy to answer

67
00:03:22,940 --> 00:03:20,250
questions about this idea of radial

68
00:03:25,220 --> 00:03:22,950
migration that stars don't necessarily

69
00:03:28,790 --> 00:03:25,230
have to have to stay where they formed

70
00:03:31,640 --> 00:03:28,800
and we think for for very good reasons

71
00:03:37,009 --> 00:03:31,650
that Proxima Alpha Centauri did not form

72
00:03:39,140 --> 00:03:37,019
in their current location so what does

73
00:03:41,210 --> 00:03:39,150
that actually look like I should also

74
00:03:43,610 --> 00:03:41,220
mention that in this sort of

75
00:03:46,490 --> 00:03:43,620
proof-of-concept study we were treating

76
00:03:49,580 --> 00:03:46,500
Alpha Centauri as as a single mass

77
00:03:51,199 --> 00:03:49,590
rather than rather than two bodies just

78
00:03:54,290 --> 00:03:51,209
because of the difficulty of modeling

79
00:03:58,940 --> 00:03:54,300
the dynamics of those of those bodies of

80
00:04:01,729 --> 00:03:58,950
the three body dynamics so we we built a

81
00:04:03,949 --> 00:04:01,739
secular model for the Galactic and tides

82
00:04:06,170 --> 00:04:03,959
and the stellar encounters and looked at

83
00:04:09,110 --> 00:04:06,180
many different possible orbits that

84
00:04:13,340 --> 00:04:09,120
próxima could have started with some of

85
00:04:15,560 --> 00:04:13,350
these configurations actually will go

86
00:04:19,099 --> 00:04:15,570
through having these close approaches

87
00:04:22,250 --> 00:04:19,109
one I'm showing here the distance on the

88
00:04:26,270 --> 00:04:22,260

right basically this is the a pastor on

89
00:04:30,050 --> 00:04:26,280
periastron and semi semi-major axis or a

90
00:04:33,080 --> 00:04:30,060
pastor on periastron of Proxima and

91
00:04:36,050 --> 00:04:33,090
Alpha Centauri a and B as a function of

92
00:04:36,320 --> 00:04:36,060
time this is billions of years and then

93
00:04:39,710 --> 00:04:36,330
the

94
00:04:42,679 --> 00:04:39,720
it spends a lot of time at high

95
00:04:45,050 --> 00:04:42,689
eccentricity the dash line refers to

96
00:04:48,740 --> 00:04:45,060
time of radial migration when it moved

97
00:04:51,499 --> 00:04:48,750
from its formation location to its

98
00:04:53,890 --> 00:04:51,509
current location but what you can see in

99
00:04:56,839 --> 00:04:53,900
this particular configuration is that

100
00:04:59,839 --> 00:04:56,849
they actually get within a few hundred

101
00:05:03,649 --> 00:04:59,849
au of each other many of the simulations

102
00:05:05,480 --> 00:05:03,659
that we looked at actually do this and

103
00:05:07,820 --> 00:05:05,490
if I actually build some histograms

104
00:05:12,320 --> 00:05:07,830
based on those simulations what you can

105
00:05:13,879 --> 00:05:12,330
see here are I've taken the minimum peri

106
00:05:17,059 --> 00:05:13,889
Center location and all of these

107
00:05:18,200 --> 00:05:17,069
different configurations and bend them

108
00:05:20,390 --> 00:05:18,210
accordingly

109
00:05:23,420 --> 00:05:20,400
according to their initial eccentricity

110
00:05:25,480 --> 00:05:23,430
semi-major axis and inclination the

111
00:05:28,999 --> 00:05:25,490
black line here represents

112
00:05:32,450 --> 00:05:29,009
configurations that never had close

113
00:05:35,029 --> 00:05:32,460

approaches within 200 au purple our

114
00:05:37,909 --> 00:05:35,039
simulations where they did approach

115
00:05:41,959 --> 00:05:37,919
within 200 au orange within a hundred

116
00:05:44,209 --> 00:05:41,969
and red within 40 and noting that Apple

117
00:05:47,409 --> 00:05:44,219
Apple Center for alpha sin a and B is

118
00:05:49,519 --> 00:05:47,419
about 36 au this is actually these

119
00:05:51,860 --> 00:05:49,529
configurations are actually probably

120
00:05:54,320 --> 00:05:51,870
destructive to the stellar system in

121
00:05:56,839 --> 00:05:54,330
addition to planetary systems and so

122
00:05:59,480 --> 00:05:56,849
we're still trying to understand that

123
00:06:01,459 --> 00:05:59,490
since we're haven't we're still working

124
00:06:04,850 --> 00:06:01,469
on models of the three body dynamics

125
00:06:09,499 --> 00:06:04,860
here but again just treating alpha sin

126
00:06:12,079 --> 00:06:09,509
as as a point mass we decided to run

127
00:06:14,689 --> 00:06:12,089
some n-body simulations to look at what

128
00:06:16,850 --> 00:06:14,699
a close passage does to a planetary

129
00:06:18,529 --> 00:06:16,860
system and I've modelled several

130
00:06:21,589 --> 00:06:18,539
different flavors of planetary systems

131
00:06:23,990 --> 00:06:21,599
one of course is just Proxima be the

132
00:06:25,730 --> 00:06:24,000
planet that we know about so one of the

133
00:06:27,709 --> 00:06:25,740
things we want to know of course is how

134
00:06:29,629 --> 00:06:27,719
does this close approach affect the

135
00:06:31,909 --> 00:06:29,639
planet that we know about assuming that

136
00:06:35,059 --> 00:06:31,919
it's the only planet in the system so I

137
00:06:37,430 --> 00:06:35,069
actually am showing here one simulation

138
00:06:40,850 --> 00:06:37,440

where Alpha Centauri and Proxima get

139
00:06:45,399 --> 00:06:40,860
within 4 tau of each other and Proxima B

140
00:06:47,659 --> 00:06:45,409
starts with a relatively high

141
00:06:50,450 --> 00:06:47,669
eccentricity and as you can see there's

142
00:06:52,820 --> 00:06:50,460
not much happening with the

143
00:06:56,270 --> 00:06:52,830
the semi-major axis a pest Ron or

144
00:06:58,879 --> 00:06:56,280
periastron or the eccentricity we see a

145
00:07:00,409 --> 00:06:58,889
little pulse just as the as during the

146
00:07:01,939 --> 00:07:00,419
close encounter the center of the mass

147
00:07:04,999 --> 00:07:01,949
of the system is shifting a little bit

148
00:07:08,870 --> 00:07:05,009
but it quickly relaxes back to its

149
00:07:10,820 --> 00:07:08,880
original value and so we would say that

150
00:07:12,200 --> 00:07:10,830
that these close encounters are not

151
00:07:14,330 --> 00:07:12,210
going to have much of an impact on

152
00:07:15,980 --> 00:07:14,340
próxima B if it's the only planet in the

153
00:07:19,309 --> 00:07:15,990
system

154
00:07:20,930 --> 00:07:19,319
now just shifting to something analogous

155
00:07:23,240 --> 00:07:20,940
to what Kaiba doll did I took

156
00:07:26,779 --> 00:07:23,250
solar system gas giants place them at

157
00:07:29,570 --> 00:07:26,789
their known locations around instead of

158
00:07:32,510 --> 00:07:29,580
in the solar system around Proxima and

159
00:07:34,939 --> 00:07:32,520
looked at what a posting post approach

160
00:07:38,990 --> 00:07:34,949
with Alpha Centauri does to that system

161
00:07:42,499 --> 00:07:39,000
this is one where alpha and Proxima get

162
00:07:45,740 --> 00:07:42,509
within 200 au of each other and as you

163
00:07:49,279 --> 00:07:45,750

can see the the distances of the planets

164
00:07:52,969 --> 00:07:49,289
that a pastor on semi major axis and

165
00:07:55,820 --> 00:07:52,979
periastron of Jupiter Saturn Uranus and

166
00:07:57,920 --> 00:07:55,830
Neptune this is the time of the close

167
00:07:59,540 --> 00:07:57,930
approach after the close approach to

168
00:08:01,490 --> 00:07:59,550
Neptune and Uranus actually end up on

169
00:08:03,560 --> 00:08:01,500
crossing orbits so this is something

170
00:08:05,240 --> 00:08:03,570
that is really bad for stability of the

171
00:08:07,279 --> 00:08:05,250
system this is something where we would

172
00:08:11,209 --> 00:08:07,289
expect one of the planets to get ejected

173
00:08:17,439 --> 00:08:11,219
or or some other devastating consequence

174
00:08:22,580 --> 00:08:20,540
yeah so the point is this is actually

175
00:08:24,830 --> 00:08:22,590
the best-case scenario that I ran for

176
00:08:27,680 --> 00:08:24,840
this type of extended planetary system

177
00:08:30,529 --> 00:08:27,690
in most of them one of the planets

178
00:08:33,889 --> 00:08:30,539
Uranus or Neptune gets ejected almost

179
00:08:36,139 --> 00:08:33,899
immediately after the encounter but what

180
00:08:39,199 --> 00:08:36,149
we'll argue based on this is that

181
00:08:42,769 --> 00:08:39,209
planets that are that if planets ever

182
00:08:45,769 --> 00:08:42,779
did exist for tens of a you from Proxima

183
00:08:48,230 --> 00:08:45,779
it this is bad news for them these kinds

184
00:08:52,519 --> 00:08:48,240
of close approaches so if it did ever

185
00:08:54,560 --> 00:08:52,529
have planetary systems like this even

186
00:08:56,780 --> 00:08:54,570
smaller mass most likely since gas

187
00:08:59,030 --> 00:08:56,790
giants are not as common around M dwarfs

188
00:09:02,000 --> 00:08:59,040

and these close approaches occurred then

189
00:09:03,500 --> 00:09:02,010
we would expect that there are but there

190
00:09:04,190 --> 00:09:03,510
wouldn't be this extended type of

191
00:09:08,389 --> 00:09:04,200
planetary

192
00:09:10,009 --> 00:09:08,399
orbiting próxima but of course this has

193
00:09:11,960 --> 00:09:10,019
the caveat that we didn't model the

194
00:09:14,000 --> 00:09:11,970
triple star dynamics because it's

195
00:09:16,280 --> 00:09:14,010
sufficiently complicated this can

196
00:09:19,310 --> 00:09:16,290
actually modify the effects of close

197
00:09:22,759 --> 00:09:19,320
approaches this is a test simulation by

198
00:09:25,269 --> 00:09:22,769
Nate cabe showing what happens if you

199
00:09:28,400 --> 00:09:25,279
place a tertiary around an inner binary

200
00:09:29,990 --> 00:09:28,410
without resolving that inner binary you

201
00:09:32,930 --> 00:09:30,000
can see that it gets within a few

202
00:09:35,439 --> 00:09:32,940
hundred au but if you actually resolve

203
00:09:38,509 --> 00:09:35,449
the effects of that inner binary the

204
00:09:40,790 --> 00:09:38,519
faster precession rate actually shields

205
00:09:42,290 --> 00:09:40,800
the the tertiary from these close

206
00:09:44,569 --> 00:09:42,300
approaches and so this is something that

207
00:09:45,920 --> 00:09:44,579
we still need to consider we're doing

208
00:09:48,230 --> 00:09:45,930
that in sort of a two-pronged approach

209
00:09:51,319 --> 00:09:48,240
one is using our secular model and

210
00:09:55,879 --> 00:09:51,329
modeling the triple star dynamics as a

211
00:09:59,269 --> 00:09:55,889
quadrupole this shows the effects of the

212
00:10:04,730 --> 00:09:59,279
adding the quadrupole moment where in

213
00:10:07,490 --> 00:10:04,740

red this is combining a and B the inner

214
00:10:09,860 --> 00:10:07,500
binary and then in blue resolving their

215
00:10:12,259 --> 00:10:09,870
effects in a quadrupole moment and then

216
00:10:13,880 --> 00:10:12,269
of course the secular approximation

217
00:10:17,300 --> 00:10:13,890
breaks down so we will still need to

218
00:10:19,850 --> 00:10:17,310
resort to make caves in body approach

219
00:10:21,380 --> 00:10:19,860
where necessary so we'll be using this

220
00:10:24,500 --> 00:10:21,390
to try to map out lots of different

221
00:10:27,069 --> 00:10:24,510
possible histories of the system of

222
00:10:36,439 --> 00:10:27,079
Alpha Centauri and Proxima Centauri and

223
00:10:36,449 --> 00:10:44,920
few questions

224
00:10:57,880 --> 00:10:55,000
I answered them all I guess great talk o

225
00:11:00,730 --> 00:10:57,890
me so my mind was floating off to our

226
00:11:04,570 --> 00:11:00,740
solar system what implications do you

227
00:11:06,940 --> 00:11:04,580
have for early evolution around the Sun

228
00:11:09,640 --> 00:11:06,950
does it imply that maybe there was a

229
00:11:13,780 --> 00:11:09,650
another star nearby from what you did

230
00:11:15,910 --> 00:11:13,790
for the Sun you know I

231
00:11:17,200 --> 00:11:15,920
that's a great question I'm not entirely

232
00:11:19,510 --> 00:11:17,210
sure how to answer that

233
00:11:24,010 --> 00:11:19,520
knate knate cave is written several

234
00:11:26,079 --> 00:11:24,020
papers on the motion of the Sun moving

235
00:11:28,870 --> 00:11:26,089
through the galaxy I think the the

236
00:11:30,970 --> 00:11:28,880
implication is that the Sun has been

237
00:11:34,230 --> 00:11:30,980
alone for a long time considering that

238
00:11:37,960 --> 00:11:34,240

we have this extended system although

239
00:11:41,230 --> 00:11:37,970
it's I'm not sure that anyone has

240
00:11:43,000 --> 00:11:41,240
explored yet what effects that may if

241
00:11:45,220 --> 00:11:43,010
the Sun formed in a cluster and there

242
00:11:47,440 --> 00:11:45,230
were other stars that were close and the

243
00:11:50,170 --> 00:11:47,450
Sun was later rejected what effect that

244
00:11:53,890 --> 00:11:50,180
may have had on sort of the formation of

245
00:11:55,810 --> 00:11:53,900
the the of the solar system it's an

246
00:12:00,760 --> 00:11:55,820
interesting Avenue to explore for sure

247
00:12:02,710 --> 00:12:00,770
yeah hi this is Renee Heller umm so

248
00:12:04,840 --> 00:12:02,720
given the opposite separation of say

249
00:12:07,420 --> 00:12:04,850
thirteen thousand au between the a B

250
00:12:09,460 --> 00:12:07,430
binary and C approxima it gives an

251
00:12:12,250 --> 00:12:09,470
obligate period of say 100,000 years say

252
00:12:16,030 --> 00:12:12,260
ten to the sides around six hundred

253
00:12:18,940 --> 00:12:16,040
thousand is the latest result as a real

254
00:12:21,430 --> 00:12:18,950
estate six excuse me ten to six years

255
00:12:22,180 --> 00:12:21,440
the system is tuned to the I don't nine

256
00:12:24,519 --> 00:12:22,190
years old

257
00:12:26,470 --> 00:12:24,529
yeah gives ten to the three orbits a

258
00:12:29,350 --> 00:12:26,480
thousand orbits only since the system

259
00:12:31,780 --> 00:12:29,360
has been existing so from the planetary

260
00:12:34,300 --> 00:12:31,790
regime when we consider tides we're

261
00:12:37,180 --> 00:12:34,310
talking about millions and hundreds of

262
00:12:38,970 --> 00:12:37,190
millions of years or orbits sure and so

263
00:12:42,310 --> 00:12:38,980

intuitively I wouldn't guess that

264
00:12:44,380 --> 00:12:42,320
galactic tides are actually haven't

265
00:12:46,630 --> 00:12:44,390
actually been effective over say

266
00:12:49,060 --> 00:12:46,640
thousand orbits of próxima around the a

267
00:12:51,730 --> 00:12:49,070
B binary so what's actually the effect

268
00:12:53,710 --> 00:12:51,740
of the galactic tides on the orbital

269
00:12:54,940 --> 00:12:53,720
evolution as part of your simulation ah

270
00:12:57,010 --> 00:12:54,950
good question

271
00:12:59,230 --> 00:12:57,020
so I'm sorry if that wasn't entirely

272
00:13:01,090 --> 00:12:59,240
clear it's the the galactic tides were

273
00:13:03,699 --> 00:13:01,100
aren't going to affect clothes things

274
00:13:07,660 --> 00:13:03,709
like the planets the effect is that it

275
00:13:10,480 --> 00:13:07,670
affects the it changes the shape of

276
00:13:12,970 --> 00:13:10,490
Proxima Alpha Sens orbit and so what

277
00:13:14,560 --> 00:13:12,980
happens is that over long timescales you

278
00:13:16,420 --> 00:13:14,570
can have some of these close approaches

279
00:13:18,340 --> 00:13:16,430
or you're right that that there's not

280
00:13:21,400 --> 00:13:18,350
going to be very many orbits there's a

281
00:13:22,510 --> 00:13:21,410
thousand ish orbit but it only takes a

282
00:13:24,519 --> 00:13:22,520
handful

283
00:13:28,170 --> 00:13:24,529
it only takes a single close approach to

284
00:13:30,100 --> 00:13:28,180
disrupt a an extended planetary system

285
00:13:33,100 --> 00:13:30,110
does that answer your question

286
00:13:36,070 --> 00:13:33,110
I was small one written about the

287
00:13:37,660 --> 00:13:36,080
collective tides there's a tidal drag of

288
00:13:40,000 --> 00:13:37,670

the Galactic mid plane as I understood

289
00:13:41,650 --> 00:13:40,010
its work including models so over a

290
00:13:43,360 --> 00:13:41,660
thousand orbits I wouldn't expect the

291
00:13:45,579 --> 00:13:43,370
Galactic mid plane to have a significant

292
00:13:50,949 --> 00:13:45,589
effect of the orbital perturbation of

293
00:13:52,420 --> 00:13:50,959
próxima around the binary which is what

294
00:13:57,579 --> 00:13:52,430
I thought you would include in the model

295
00:14:01,720 --> 00:13:57,589
oh so the the orbital effects of the of

296
00:14:04,319 --> 00:14:01,730
the inner binary are small at the at the

297
00:14:06,970 --> 00:14:04,329
distances that we're talking about of

298
00:14:10,389 --> 00:14:06,980
and I think I'll bug you in the

299
00:14:12,490 --> 00:14:10,399
coffee-break again is okay sorry I'm not

300
00:14:16,750 --> 00:14:12,500
I'm not sure I understand what you're

301
00:14:17,690 --> 00:14:16,760
asking all right let's think Russell