
AbSciCon
2017
MESA, ARIZONA

1
00:00:00,220 --> 00:00:12,330
[Music]

2
00:00:18,060 --> 00:00:15,570
so shifting gears actually downshifting

3
00:00:22,890 --> 00:00:18,070
back to basics finding planets in the

4
00:00:24,210 --> 00:00:22,900
habitable zone so we probably have heard

5
00:00:24,780 --> 00:00:24,220
about the k2 mission which is the

6
00:00:27,030 --> 00:00:24,790
repurposed

7
00:00:28,769 --> 00:00:27,040
Kepler spacecraft so a couple years ago

8
00:00:31,290 --> 00:00:28,779
Kepler lost two of its reaction wheels

9
00:00:33,810 --> 00:00:31,300
which makes it unable to point steadily

10
00:00:35,340 --> 00:00:33,820
and significantly degrade the photometry

11
00:00:39,150 --> 00:00:35,350
that comes out of it so we're trying to

12
00:00:41,880 --> 00:00:39,160
find transiting planets with k2 but the

13
00:00:46,380 --> 00:00:41,890

telescope is essentially crippled in a

14
00:00:49,650 --> 00:00:46,390
sense and so this is what a typical

15
00:00:51,810 --> 00:00:49,660
planet hosting kepler star looks like in

16
00:00:53,760 --> 00:00:51,820
this case it's I think it's a 11th

17
00:00:57,120 --> 00:00:53,770
magnitude Kepler band star with a hot

18
00:01:00,270 --> 00:00:57,130
Jupiter this is a very similar star

19
00:01:02,520 --> 00:01:00,280
observed by k2 also 11th magnitude also

20
00:01:05,730 --> 00:01:02,530
has transiting planets and yet the data

21
00:01:08,130 --> 00:01:05,740
look terrible the raw data you could not

22
00:01:11,219 --> 00:01:08,140
buy I pick out any transits in this

23
00:01:13,649 --> 00:01:11,229
light curve I think that might be one

24
00:01:15,749 --> 00:01:13,659
but you can't be sure and Saudi trending

25
00:01:18,980 --> 00:01:15,759
is a very important part of analyzing

26
00:01:21,480 --> 00:01:18,990
data with k2 and I just wanted to

27
00:01:23,279 --> 00:01:21,490
motivate a little bit of this why is the

28
00:01:24,120 --> 00:01:23,289
data so poor with k2 so the spacecraft

29
00:01:26,099 --> 00:01:24,130
camp point

30
00:01:27,870 --> 00:01:26,109
fine but you're still observing the star

31
00:01:29,190 --> 00:01:27,880
and the star is still in your aperture

32
00:01:31,020 --> 00:01:29,200
so aren't you collecting the same amount

33
00:01:33,830 --> 00:01:31,030
of flux that would be true if you had a

34
00:01:36,179 --> 00:01:33,840
perfect detector but in real life

35
00:01:37,859 --> 00:01:36,189
detectors are not homogeneous and their

36
00:01:39,809 --> 00:01:37,869
sensitivity and so actual quantum

37
00:01:45,330 --> 00:01:39,819
efficiency variations in the pixels and

38
00:01:46,709 --> 00:01:45,340

across the pixels translate to change in

39
00:01:49,830 --> 00:01:46,719
the total flux you're receiving from the

40
00:01:53,419 --> 00:01:49,840
target that in the case of K 2 where the

41
00:01:55,679 --> 00:01:53,429
drift occurs on very short timescales

42
00:01:58,649 --> 00:01:55,689
accompanied by so the reason you have

43
00:02:01,289 --> 00:01:58,659
this jigsaw or this jagged pattern is

44
00:02:03,209 --> 00:02:01,299
that every six hours the spacecraft

45
00:02:06,770 --> 00:02:03,219
fires a thruster to come back and point

46
00:02:11,490 --> 00:02:06,780
to the original field when you convolve

47
00:02:13,380 --> 00:02:11,500
in homogeneous detector with strong

48
00:02:15,300 --> 00:02:13,390
motion you get a light curve that looks

49
00:02:17,610 --> 00:02:15,310
essentially like this now this is just

50
00:02:20,460 --> 00:02:17,620
simulated data but this is real k2

51
00:02:21,960 --> 00:02:20,470
motion and so another wise flat and

52
00:02:24,420 --> 00:02:21,970
featureless light curve which may or may

53
00:02:24,920 --> 00:02:24,430
not have transits gets degraded in this

54
00:02:27,110 --> 00:02:24,930
fashion

55
00:02:29,270 --> 00:02:27,120
and the problem at hand is we don't

56
00:02:31,459 --> 00:02:29,280
actually have this information about the

57
00:02:33,380 --> 00:02:31,469
pixel sensitivity in each pixel all we

58
00:02:35,509 --> 00:02:33,390
get is this severely downgraded low

59
00:02:39,550 --> 00:02:35,519
resolution image of what the stars doing

60
00:02:43,369 --> 00:02:39,560
over time and so what my pipeline does

61
00:02:45,259 --> 00:02:43,379
are actually sorry one slide before I

62
00:02:47,929 --> 00:02:45,269
get to that the question you might ask

63
00:02:50,259 --> 00:02:47,939

is why bother we have spacecraft like

64
00:02:53,089 --> 00:02:50,269
test coming up on line later this year

65
00:02:55,000 --> 00:02:53,099
that are going to survey the entire sky

66
00:02:58,610 --> 00:02:55,010
and find tons of more habitable planets

67
00:03:02,179 --> 00:02:58,620
I want to make a pitch here for yk2 is

68
00:03:05,000 --> 00:03:02,189
still awesome this is to scale so the

69
00:03:07,220 --> 00:03:05,010
the actual collecting area of the Kepler

70
00:03:09,830 --> 00:03:07,230
spacecraft is still much larger than

71
00:03:12,170 --> 00:03:09,840
that of Tess and so the potential noise

72
00:03:14,030 --> 00:03:12,180
floor for Kepler is still going to be

73
00:03:17,119 --> 00:03:14,040
the best out there for detecting these

74
00:03:18,770 --> 00:03:17,129
transiting planets in bulk now Tess has

75
00:03:20,209 --> 00:03:18,780
awesome properties it's going to observe

76
00:03:23,240 --> 00:03:20,219
the whole sky it's going to do it at

77
00:03:24,979 --> 00:03:23,250
much higher cadence but while we still

78
00:03:26,209 --> 00:03:24,989
have fuel for k2 we want to use it I'm

79
00:03:30,649 --> 00:03:26,219
going to continue to find Heather Bowl

80
00:03:32,930 --> 00:03:30,659
planet and so what my pipeline does is

81
00:03:33,619 --> 00:03:32,940
to use a method called pixel level

82
00:03:35,240 --> 00:03:33,629
decorrelation

83
00:03:37,009 --> 00:03:35,250
it's a machine learning model we're

84
00:03:40,729 --> 00:03:37,019
actually using information at the pixel

85
00:03:42,679 --> 00:03:40,739
level and you build up some large matrix

86
00:03:44,899 --> 00:03:42,689
of regressors and you do some linear

87
00:03:47,990 --> 00:03:44,909
algebra and it's based on stuff that

88
00:03:49,399 --> 00:03:48,000

Drake Deming has done for Spitzer but

89
00:03:51,710 --> 00:03:49,409
basically at the end of the day I won't

90
00:03:53,179 --> 00:03:51,720
get into the math of this you start with

91
00:03:55,539 --> 00:03:53,189
the like or they look like this and at

92
00:03:58,309 --> 00:03:55,549
the end of the day you actually recover

93
00:04:00,499 --> 00:03:58,319
the original Kepler precision for bright

94
00:04:02,420 --> 00:04:00,509
stars which allows you to do very

95
00:04:02,869 --> 00:04:02,430
precise photometry and find transiting

96
00:04:05,449 --> 00:04:02,879
planets

97
00:04:07,429 --> 00:04:05,459
now you can look back and see in fact

98
00:04:09,439 --> 00:04:07,439
that these are comparable precision at

99
00:04:11,719 --> 00:04:09,449
the same magnitude and if you look at

100
00:04:15,050 --> 00:04:11,729
the distribution of magnitudes for stars

101
00:04:17,360 --> 00:04:15,060
d trended with Everest which is the RK 2

102
00:04:19,580 --> 00:04:17,370
pipeline you can see that the

103
00:04:21,289 --> 00:04:19,590
photometric precision as a function of

104
00:04:22,490 --> 00:04:21,299
magnitude follows a very similar

105
00:04:24,200 --> 00:04:22,500
distribution to that of the original

106
00:04:27,140 --> 00:04:24,210
Kepler mission before the reaction

107
00:04:28,430 --> 00:04:27,150
wheels failed and so blue is k2d trended

108
00:04:31,999 --> 00:04:28,440
with Everest yellow is the original

109
00:04:33,800 --> 00:04:32,009
Kepler up until about magnitude 15 or 14

110
00:04:36,570 --> 00:04:33,810
or 15 we recover original Kappa

111
00:04:40,440 --> 00:04:38,670
the science is coming out of this so

112
00:04:43,680 --> 00:04:40,450
this is work in preparation led by Ethan

113
00:04:45,600 --> 00:04:43,690

Cruz via University of Washington we are

114
00:04:46,890 --> 00:04:45,610
finding a lot more planets that have

115
00:04:49,890 --> 00:04:46,900
previously been missed by other

116
00:04:52,170 --> 00:04:49,900
pipelines and in particular relevant to

117
00:04:53,550 --> 00:04:52,180
today's session is that little region

118
00:04:55,860 --> 00:04:53,560
there which is a habitable zone now

119
00:04:58,010 --> 00:04:55,870
these are this is the very generous

120
00:05:01,110 --> 00:04:58,020
optimistic habitable zone bounded by

121
00:05:02,490 --> 00:05:01,120
Venus here and Mars here and so it might

122
00:05:05,340 --> 00:05:02,500
be a little optimistic about these ones

123
00:05:07,470 --> 00:05:05,350
near the edge but three of these points

124
00:05:10,320 --> 00:05:07,480
here are new and have not been found by

125
00:05:11,700 --> 00:05:10,330
previous pipelines if you're interested

126
00:05:12,960 --> 00:05:11,710
in planets outside the habitable zone

127
00:05:15,060 --> 00:05:12,970
another cool thing that's coming out of

128
00:05:17,160 --> 00:05:15,070
this is we are finding tons of more

129
00:05:21,180 --> 00:05:17,170
multi-planet systems with our pipeline

130
00:05:23,580 --> 00:05:21,190
and so in total expect something like

131
00:05:26,730 --> 00:05:23,590
300 more k2 planets in the first eight

132
00:05:28,530 --> 00:05:26,740
campaigns several multis and three to

133
00:05:30,240 --> 00:05:28,540
four new small habitable zone planets

134
00:05:32,370 --> 00:05:30,250
coming soon there's a little family

135
00:05:33,840 --> 00:05:32,380
portrait of the four this one is

136
00:05:34,890 --> 00:05:33,850
slightly outside the habitable zone

137
00:05:36,270 --> 00:05:34,900
we're hoping that revised other

138
00:05:41,610 --> 00:05:36,280

parameters might actually scatter it in

139
00:05:43,050 --> 00:05:41,620
it would be very cool I wanted to so

140
00:05:44,970 --> 00:05:43,060
this is very recent stuff I wasn't

141
00:05:46,800 --> 00:05:44,980
planning on talking about this but since

142
00:05:48,210 --> 00:05:46,810
k2 observed Travis one I think that's

143
00:05:50,010 --> 00:05:48,220
the perfect time to talk about a

144
00:05:52,710 --> 00:05:50,020
habitable planets in the potentially

145
00:05:54,410 --> 00:05:52,720
habitable planets in Trappist now many

146
00:05:57,960 --> 00:05:54,420
of you know Trappist one seven

147
00:06:00,750 --> 00:05:57,970
transiting planets to nature papers

148
00:06:02,940 --> 00:06:00,760
earlier this year and last year kay to

149
00:06:07,200 --> 00:06:02,950
observe the Trappist one system recently

150
00:06:10,530 --> 00:06:07,210
and this is the raw light curve you can

151
00:06:13,560 --> 00:06:10,540
see some modulation due to star spots

152
00:06:15,420 --> 00:06:13,570
you can see some low laying outliers

153
00:06:18,170 --> 00:06:15,430
they could be transits it could just be

154
00:06:21,720 --> 00:06:18,180
noise after you de tren this light curve

155
00:06:24,060 --> 00:06:21,730
it is much clearer and in fact almost

156
00:06:25,620 --> 00:06:24,070
all of these points below the continuum

157
00:06:27,000 --> 00:06:25,630
are transit and almost all of these

158
00:06:29,460 --> 00:06:27,010
points above the continuum are flares

159
00:06:31,710 --> 00:06:29,470
and so this star is either regular

160
00:06:33,540 --> 00:06:31,720
transit or a flare happening about 20%

161
00:06:37,410 --> 00:06:33,550
of the time this is the richest data set

162
00:06:38,790 --> 00:06:37,420
we know of for EXO planet transits and

163
00:06:41,420 --> 00:06:38,800

so it's very we're very lucky to have

164
00:06:45,450 --> 00:06:41,430
been able to play with this with k2

165
00:06:47,659 --> 00:06:45,460
here's a family portrait of the six the

166
00:06:49,879 --> 00:06:47,669
first six Trappist planets

167
00:06:53,119 --> 00:06:49,889
this is seen in k2 short cadence they

168
00:06:55,580 --> 00:06:53,129
trended with Everest this is the longest

169
00:06:57,409 --> 00:06:55,590
baseline light curve we have of the

170
00:07:00,080 --> 00:06:57,419
system so far just because k2 stared at

171
00:07:05,209 --> 00:07:00,090
it almost uninterrupted the leaf for 480

172
00:07:07,309 --> 00:07:05,219
days and so we we can do we're still

173
00:07:08,869 --> 00:07:07,319
working on transit timing variations you

174
00:07:10,519 --> 00:07:08,879
can usually constrain the masses very

175
00:07:12,860 --> 00:07:10,529
well those actually paper on the archive

176
00:07:15,290 --> 00:07:12,870
doing this we think we can revise the

177
00:07:16,700 --> 00:07:15,300
masses a little better but there's a

178
00:07:20,179 --> 00:07:16,710
very cool stuff coming out of this data

179
00:07:22,580 --> 00:07:20,189
out of this data set here are the

180
00:07:25,399 --> 00:07:22,590
habitable zone planets EF and G or in

181
00:07:27,469 --> 00:07:25,409
the conservative habitable zone D is a

182
00:07:33,709 --> 00:07:27,479
little near the edge perhaps

183
00:07:36,230 --> 00:07:33,719
uncomfortably so and I'm missing H from

184
00:07:38,749 --> 00:07:36,240
that diagram and that's because so in

185
00:07:41,420 --> 00:07:38,759
our paper from last month that we put on

186
00:07:45,079 --> 00:07:41,430
archive we used k2 to confirm H and

187
00:07:48,529 --> 00:07:45,089
detect its period and here is the raw

188
00:07:49,999 --> 00:07:48,539

data and you can see that after

189
00:07:52,399 --> 00:07:50,009
successive D trending the transit

190
00:07:54,890 --> 00:07:52,409
appears you would not have been able to

191
00:08:00,379 --> 00:07:54,900
see that from the from the raw Laker and

192
00:08:03,439 --> 00:08:00,389
so here is the folded light curve on the

193
00:08:05,149 --> 00:08:03,449
four transits of H that we detected this

194
00:08:06,980 --> 00:08:05,159
planet so the reason I'm putting the

195
00:08:09,260 --> 00:08:06,990
slide up here is because H is smaller

196
00:08:10,790 --> 00:08:09,270
than the earth and it's further it's

197
00:08:12,559 --> 00:08:10,800
outside the habitable zone beyond the

198
00:08:16,429 --> 00:08:12,569
habitable zone and yet k2 can still

199
00:08:17,779 --> 00:08:16,439
detect it and so k2 because of its if

200
00:08:20,719 --> 00:08:17,789
you'da trend it properly just because if

201
00:08:23,959 --> 00:08:20,729
it's awesome collecting power is still a

202
00:08:25,760 --> 00:08:23,969
great observer observatory for detecting

203
00:08:31,670 --> 00:08:25,770
planets in the habitable zone especially

204
00:08:32,959 --> 00:08:31,680
small ones and we have fuel left on the

205
00:08:34,490 --> 00:08:32,969
spacecraft and so we should continue to

206
00:08:36,589 --> 00:08:34,500
do that

207
00:08:40,430 --> 00:08:36,599
and I just wanted to conclude very

208
00:08:43,370 --> 00:08:40,440
briefly with some links here so the

209
00:08:45,590 --> 00:08:43,380
everest pipeline is open source you can

210
00:08:48,230 --> 00:08:45,600
check it out on github or you can pip

211
00:08:50,900 --> 00:08:48,240
install it if you use python and you can

212
00:08:53,030 --> 00:08:50,910
check out our papers here we are going

213
00:08:56,780 --> 00:08:53,040

to continue d trending all the campaigns

214
00:09:01,610 --> 00:08:56,790
for k2 a long-ago spacecraft spacecraft

215
00:09:05,210 --> 00:09:03,470
keep an eye out for our paper with the

216
00:09:14,330 --> 00:09:05,220
with a new habits on planets so thank

217
00:09:16,460 --> 00:09:14,340
you all right we have time for some

218
00:09:19,490 --> 00:09:16,470
questions if you're able to be to come

219
00:09:21,910 --> 00:09:19,500
up to the microphone not telescopes

220
00:09:24,710 --> 00:09:21,920
wrong word

221
00:09:27,230 --> 00:09:24,720
that was great um do you have stellar

222
00:09:30,800 --> 00:09:27,240
information for those habitable zone

223
00:09:32,420 --> 00:09:30,810
planets what do you mean by stellar

224
00:09:34,460 --> 00:09:32,430
information what kind of stress

225
00:09:37,880 --> 00:09:34,470
oh so one is an M and I think the other

226
00:09:40,190 --> 00:09:37,890
three are K are these the new one yeah

227
00:09:42,500 --> 00:09:40,200
then maybe there early am I'm not I'm

228
00:09:51,130 --> 00:09:42,510
not exactly sure I'd have to ask Ethan

229
00:09:51,140 --> 00:09:56,060
yeah

230
00:10:03,470 --> 00:10:00,139
okay sorry can you say anything about

231
00:10:06,019 --> 00:10:03,480
the flaring on Travis one from the k2

232
00:10:07,970 --> 00:10:06,029
bikers yes so we have a paper in

233
00:10:17,420 --> 00:10:07,980
preparation on that I'm not leading that

234
00:10:25,940 --> 00:10:20,540
I can't remember the flaring rate off

235
00:10:27,560 --> 00:10:25,950
the top of my head what can we say so so

236
00:10:31,160 --> 00:10:27,570
based on the flaring and the and the

237
00:10:33,260 --> 00:10:31,170
rotation period which is three days it's

238
00:10:35,240 --> 00:10:33,270

consistent all we can say in the paper

239
00:10:39,650 --> 00:10:35,250
at least is that it's consistent with

240
00:10:41,600 --> 00:10:39,660
the middle-aged late I'm dwarf I don't

241
00:10:43,100 --> 00:10:41,610
know what what exactly they're working

242
00:10:47,750 --> 00:10:43,110
on in the flare modeling right now with

243
00:10:50,180 --> 00:10:47,760
it thank you John Grunsfeld NASA have

244
00:10:52,700 --> 00:10:50,190
you thought it all about contemporaneous

245
00:10:55,250 --> 00:10:52,710
parallel observations with k2 and tests

246
00:10:57,050 --> 00:10:55,260
to try and you know help test Commission

247
00:10:58,880 --> 00:10:57,060
essentially or what you know what you

248
00:11:01,490 --> 00:10:58,890
could learn and with your greater

249
00:11:04,280 --> 00:11:01,500
sensitivity you know so that the test

250
00:11:04,790 --> 00:11:04,290
can start discovering faster that's a

251
00:11:07,880 --> 00:11:04,800
good idea

252
00:11:09,260 --> 00:11:07,890
no I had not thought about that yeah

253
00:11:13,460 --> 00:11:09,270
that's a good question for the for the

254
00:11:13,700 --> 00:11:13,470
Kepler team yeah something to think

255
00:11:16,640 --> 00:11:13,710
about

256
00:11:17,560 --> 00:11:16,650
thank you all right let's give a Rodrigo