
AbSciCon
2017
MESA, ARIZONA

1
00:00:16,470 --> 00:00:12,250
[Music]

2
00:00:17,939 --> 00:00:16,480
yeah my name is Charlie lineweaver this

3
00:00:20,429 --> 00:00:17,949
is work that I've done with my PhD

4
00:00:22,679 --> 00:00:20,439
student hi young one whose image is

5
00:00:25,679 --> 00:00:22,689
right there unfortunately he couldn't

6
00:00:28,859 --> 00:00:25,689
come so it's about the D volatilization

7
00:00:30,720 --> 00:00:28,869
that leads to rocky planets and I showed

8
00:00:32,010 --> 00:00:30,730
a picture of the comet here because

9
00:00:34,770 --> 00:00:32,020
that's a good example of D

10
00:00:38,790 --> 00:00:34,780
volatilization of material as it comes

11
00:00:40,830 --> 00:00:38,800
closer to the Sun all right so lots of

12
00:00:43,170 --> 00:00:40,840
stars in our galaxy half these are half

13
00:00:47,700 --> 00:00:43,180

a billion of the 300 billion in the

14
00:00:49,500 --> 00:00:47,710
galaxy and bunk and stars form in the

15
00:00:52,050 --> 00:00:49,510
clumps in molecular clouds in the plane

16
00:00:54,840 --> 00:00:52,060
of the galaxy and as you can see from

17
00:00:56,280 --> 00:00:54,850
this when you have a bunch of stars here

18
00:00:57,840 --> 00:00:56,290
particularly the OB stars they are

19
00:00:59,760 --> 00:00:57,850
putting out lots of UV and they're

20
00:01:00,870 --> 00:00:59,770
creating these fingers everywhere so

21
00:01:05,760 --> 00:01:00,880
that's an example of the D

22
00:01:08,249 --> 00:01:05,770
volatilization in a molecular cloud so

23
00:01:09,899 --> 00:01:08,259
here's an accretion disk and so here for

24
00:01:12,840 --> 00:01:09,909
example that tiny accretion disk in this

25
00:01:15,990 --> 00:01:12,850
OB over here pushing away this gas here

26
00:01:17,520 --> 00:01:16,000
you can see dust is blocking out the

27
00:01:19,859 --> 00:01:17,530
star here and we're getting lots of

28
00:01:21,719 --> 00:01:19,869
volatiles along these Jets and here's a

29
00:01:23,789 --> 00:01:21,729
picture of what's going on essentially

30
00:01:24,410 --> 00:01:23,799
we were moving good gas and leaving the

31
00:01:26,969 --> 00:01:24,420
dust

32
00:01:29,340 --> 00:01:26,979
now here's another picture you may have

33
00:01:31,019 --> 00:01:29,350
heard that when these protoplanetary

34
00:01:32,969 --> 00:01:31,029
discs are there and they're trying to

35
00:01:34,919 --> 00:01:32,979
create that start turns on it's blowing

36
00:01:36,870 --> 00:01:34,929
out the volatiles from the interior and

37
00:01:38,730 --> 00:01:36,880
that's essentially what is responsible

38
00:01:43,139 --> 00:01:38,740

for the rocky planets that will end up

39
00:01:45,029 --> 00:01:43,149
there and so we have to spend lots and

40
00:01:47,669 --> 00:01:45,039
lots of planets lately there's a few

41
00:01:51,510 --> 00:01:47,679
thousand from the red ones our cups the

42
00:01:52,980 --> 00:01:51,520
red ones are from Kepler and and they're

43
00:01:54,899 --> 00:01:52,990
different techniques here here's the

44
00:01:59,580 --> 00:01:54,909
earth like once the rocky ones are down

45
00:02:01,649 --> 00:01:59,590
here in general and we would we so we

46
00:02:03,749 --> 00:02:01,659
know the mass we know their period we

47
00:02:05,909 --> 00:02:03,759
also if we have transit and radial

48
00:02:08,190 --> 00:02:05,919
detections we can get their density and

49
00:02:09,870 --> 00:02:08,200
that's what this plot is about so dense

50
00:02:11,490 --> 00:02:09,880
this is a slightly older plot but lots

51
00:02:13,620 --> 00:02:11,500
and lots of new planets are being put on

52
00:02:15,120 --> 00:02:13,630
here because we're getting more planets

53
00:02:19,949 --> 00:02:15,130
that we know both the radial velocity

54
00:02:22,950 --> 00:02:19,959
and the and the transits for so dense

55
00:02:25,670 --> 00:02:22,960
high density low density now one example

56
00:02:28,369 --> 00:02:25,680
of AD volatilized piece of

57
00:02:29,990 --> 00:02:28,379
stellar nebula is the earth and so when

58
00:02:32,089 --> 00:02:30,000
we plot the earth compared to the Sun

59
00:02:34,009 --> 00:02:32,099
you can see that did some elements

60
00:02:35,599 --> 00:02:34,019
particularly the noble gases there's

61
00:02:37,580 --> 00:02:35,609
very very little in the earth than blue

62
00:02:39,140 --> 00:02:37,590
and other elements which are very

63
00:02:41,330 --> 00:02:39,150

refractory you can see that the Earth's

64
00:02:43,879 --> 00:02:41,340
relative abundance and the Suns are

65
00:02:45,530 --> 00:02:43,889
pretty much identical almost in other

66
00:02:46,940 --> 00:02:45,540
words if we didn't have this star the

67
00:02:48,530 --> 00:02:46,950
Sun right there but we knew the

68
00:02:50,390 --> 00:02:48,540
abundances of the earth we could look

69
00:02:51,920 --> 00:02:50,400
around at all the stars and by matching

70
00:02:56,509 --> 00:02:51,930
the refractory elements we could figure

71
00:02:58,759 --> 00:02:56,519
out which was our mother star so now

72
00:03:00,530 --> 00:02:58,769
here a bunch of stars unfortunately this

73
00:03:03,020 --> 00:03:00,540
also is an older plot but the point is

74
00:03:05,119 --> 00:03:03,030
that stars differ in their relative

75
00:03:07,580 --> 00:03:05,129
abundances of different elements so you

76
00:03:09,649 --> 00:03:07,590
can see here that there now if there

77
00:03:11,720 --> 00:03:09,659
just a line up here that means they have

78
00:03:13,849 --> 00:03:11,730
high metallicity but the same relative

79
00:03:15,920 --> 00:03:13,859
abundances down here if it were just a

80
00:03:18,589 --> 00:03:15,930
line it would be low metallicity but the

81
00:03:20,179 --> 00:03:18,599
same relative abundances as the Sun but

82
00:03:21,679 --> 00:03:20,189
you can see that these lines go up and

83
00:03:24,949 --> 00:03:21,689
down up and down and so you get

84
00:03:27,440 --> 00:03:24,959
variations of 10 20 30 percent in the

85
00:03:29,689 --> 00:03:27,450
abundances of magnesium calcium other

86
00:03:33,080 --> 00:03:29,699
important elements that eventually will

87
00:03:38,059 --> 00:03:33,090
produce the rocky planets around that

88
00:03:40,759 --> 00:03:38,069

star so the name of the game then is to

89
00:03:43,580 --> 00:03:40,769
figure out what is let's may it be as

90
00:03:44,960 --> 00:03:43,590
precise as we can - what is the D

91
00:03:47,659 --> 00:03:44,970
volatilization that has produced the

92
00:03:50,179 --> 00:03:47,669
earth from the stellar nebula and here's

93
00:03:51,080 --> 00:03:50,189
a plot now normally earth scientists

94
00:03:53,089 --> 00:03:51,090
when they look at this these are the

95
00:03:56,089 --> 00:03:53,099
experts in Earth's what they plot here

96
00:03:57,649 --> 00:03:56,099
is see eyes up everybody's making this

97
00:04:00,439 --> 00:03:57,659
mistakes see eyes here as a

98
00:04:02,179 --> 00:04:00,449
representative of the Sun and they

99
00:04:03,979 --> 00:04:02,189
normalize - magnesium and they get a

100
00:04:05,899 --> 00:04:03,989
refractory thing here this says the

101
00:04:07,520 --> 00:04:05,909
earth and the Sun are the same and then

102
00:04:09,589 --> 00:04:07,530
there's this D volatilization here

103
00:04:13,249 --> 00:04:09,599
typically they don't use the bulk earth

104
00:04:14,990 --> 00:04:13,259
they use the primitive mantle and so we

105
00:04:16,759 --> 00:04:15,000
said oh you know what we're going to do

106
00:04:18,439 --> 00:04:16,769
a better job than these earth scientists

107
00:04:20,629 --> 00:04:18,449
first of all we're going to put error

108
00:04:21,710 --> 00:04:20,639
bars on the bulk earth and we're going

109
00:04:23,450 --> 00:04:21,720
to include the core and so we're going

110
00:04:25,249 --> 00:04:23,460
to get the elemental abundances of the

111
00:04:25,999 --> 00:04:25,259
earth with air bars and that has never

112
00:04:28,640 --> 00:04:26,009
been done before

113
00:04:30,080 --> 00:04:28,650

it's been almost done but we use what

114
00:04:32,210 --> 00:04:30,090
has been done before and did a better

115
00:04:34,430 --> 00:04:32,220
job of combining things and we think we

116
00:04:36,500 --> 00:04:34,440
have the best bulk elemental composition

117
00:04:38,629 --> 00:04:36,510
of the earth ever and you should use it

118
00:04:38,990 --> 00:04:38,639
in your future if you're interested in

119
00:04:50,120 --> 00:04:39,000
the

120
00:04:52,250 --> 00:04:50,130
is abundance normalized to aluminum now

121
00:04:53,570 --> 00:04:52,260
and aluminum is much more refractory

122
00:04:55,490 --> 00:04:53,580
than the silicon in the magnesium that I

123
00:04:59,030 --> 00:04:55,500
usually use so therefore you don't get

124
00:05:00,350 --> 00:04:59,040
that artificial increase in the you

125
00:05:03,170 --> 00:05:00,360
don't get an enrichment of the

126
00:05:05,450 --> 00:05:03,180
refractory elements and here what's

127
00:05:08,510 --> 00:05:05,460
plotted is the earth the concordant bulk

128
00:05:10,370 --> 00:05:08,520
earth in the blue and then we've also

129
00:05:12,380 --> 00:05:10,380
done what has usually been done as we

130
00:05:14,540 --> 00:05:12,390
did the primitive mantle dividing it

131
00:05:16,310 --> 00:05:14,550
into these types different element types

132
00:05:18,350 --> 00:05:16,320
and you can see that flat here and

133
00:05:19,820 --> 00:05:18,360
there's a line here so I said well you

134
00:05:21,980 --> 00:05:19,830
know what we got a flat here and a line

135
00:05:24,470 --> 00:05:21,990
here let's fit this has it been fit

136
00:05:26,330 --> 00:05:24,480
before kind of but not really so let's

137
00:05:29,090 --> 00:05:26,340
do the best job of fitting this line

138
00:05:32,390 --> 00:05:29,100

this D volatilization trend as we call

139
00:05:34,220 --> 00:05:32,400
it and when you do well first of all

140
00:05:35,930 --> 00:05:34,230
there's a difference when you look at

141
00:05:38,840 --> 00:05:35,940
plots like this make sure are they

142
00:05:41,120 --> 00:05:38,850
normalizing to see icon rights or are

143
00:05:42,680 --> 00:05:41,130
they normalizing to the Sun there's a

144
00:05:46,120 --> 00:05:42,690
difference a lot of things are the same

145
00:05:49,010 --> 00:05:46,130
but there's a very important differences

146
00:05:50,510 --> 00:05:49,020
for example here's the cut here's the C

147
00:05:52,340 --> 00:05:50,520
icon dried abundances here the solar

148
00:05:54,230 --> 00:05:52,350
photosphere abundances and you can see

149
00:05:56,210 --> 00:05:54,240
it's basically the same except for

150
00:05:58,640 --> 00:05:56,220
lithium is being burned in the Sun and

151
00:05:59,390 --> 00:05:58,650
all these have been depleted in CI

152
00:06:01,010 --> 00:05:59,400
chondrites

153
00:06:03,080 --> 00:06:01,020
plus CI contracts they have a lot of

154
00:06:04,190 --> 00:06:03,090
refractories it's the most volatile rich

155
00:06:06,409 --> 00:06:04,200
sometimes called the primitive

156
00:06:08,900 --> 00:06:06,419
meteorites that we use as a proxy for

157
00:06:12,230 --> 00:06:08,910
the Sun but in terms of these elements

158
00:06:15,170 --> 00:06:12,240
are really bad proxy so let's continue

159
00:06:18,020 --> 00:06:15,180
so highly volatile elements are nine and

160
00:06:19,909 --> 00:06:18,030
the depleted in CIS and are well

161
00:06:21,590 --> 00:06:19,919
determined in the photosphere 13

162
00:06:22,820 --> 00:06:21,600
elements without photosphere abundances

163
00:06:25,250 --> 00:06:22,830

are well determined in the meteoritic

164
00:06:28,460 --> 00:06:25,260
abundances primordial ism is burned in

165
00:06:29,030 --> 00:06:28,470
the Sun and so the whole idea is how do

166
00:06:31,850 --> 00:06:29,040
you combine

167
00:06:33,890 --> 00:06:31,860
photosphere with CI measurements to make

168
00:06:35,930 --> 00:06:33,900
the best measurements for the Sun and

169
00:06:38,210 --> 00:06:35,940
that's what we did and here's our method

170
00:06:40,130 --> 00:06:38,220
now laughter's 2009 did something very

171
00:06:41,960 --> 00:06:40,140
similar here's how she divided up those

172
00:06:44,600 --> 00:06:41,970
elements that combined them here's how

173
00:06:46,610 --> 00:06:44,610
we did this is the elements that are you

174
00:06:48,860 --> 00:06:46,620
based only on the photosphere elements

175
00:06:50,300 --> 00:06:48,870
based only on meteorites laughter's

176
00:06:52,170 --> 00:06:50,310
loves meteorites so she put most of them

177
00:06:53,700 --> 00:06:52,180
here but we did a

178
00:06:55,560 --> 00:06:53,710
average them this a stands for average

179
00:06:57,930 --> 00:06:55,570
so we average all these elements because

180
00:06:59,879 --> 00:06:57,940
both photo spheric and meteoritic

181
00:07:03,480 --> 00:06:59,889
abundances are available for those

182
00:07:05,430 --> 00:07:03,490
elements okay so when you do that you

183
00:07:07,170 --> 00:07:05,440
get a plot that looks like this but you

184
00:07:09,450 --> 00:07:07,180
can see it better down here

185
00:07:12,330 --> 00:07:09,460
the blue is photosphere the red are the

186
00:07:14,430 --> 00:07:12,340
CI chondrites and the yellow is the way

187
00:07:16,650 --> 00:07:14,440
we've combined them together to get the

188
00:07:18,960 --> 00:07:16,660

best estimate of the protis solar

189
00:07:21,080 --> 00:07:18,970
abundances and that's what we need

190
00:07:23,580 --> 00:07:21,090
because the proto solar abundances are

191
00:07:27,510 --> 00:07:23,590
what was d volatilized to produce the

192
00:07:29,339 --> 00:07:27,520
earth okay so along the way we figured

193
00:07:31,439 --> 00:07:29,349
eh why don't we do the XY and Z these

194
00:07:34,020 --> 00:07:31,449
are the mass fractions in hydrogen

195
00:07:35,370 --> 00:07:34,030
helium and everything else and it's

196
00:07:38,219 --> 00:07:35,380
interesting to know that over the last

197
00:07:39,990 --> 00:07:38,229
three decades this Z the amount the

198
00:07:41,400 --> 00:07:40,000
fraction of material in the Sun that's

199
00:07:43,140 --> 00:07:41,410
not hydrogen helium has been going down

200
00:07:45,029 --> 00:07:43,150
from one point eight nine all the way

201
00:07:50,159 --> 00:07:45,039
down to about one point four oh right

202
00:07:53,670 --> 00:07:50,169
here now when you plot up this now the

203
00:07:55,320 --> 00:07:53,680
Sun so here is the Sun and the blue is

204
00:07:56,640 --> 00:07:55,330
the earth and you can see that they're

205
00:07:58,649 --> 00:07:56,650
up and down up and down some of them are

206
00:08:00,029 --> 00:07:58,659
identical and some of them are developed

207
00:08:02,670 --> 00:08:00,039
alized some of them are really developed

208
00:08:04,020 --> 00:08:02,680
eyes and when you plot that as a

209
00:08:06,120 --> 00:08:04,030
function of condensation temperature

210
00:08:08,399 --> 00:08:06,130
this is notice this is linear

211
00:08:09,480 --> 00:08:08,409
condensation temperature not log you get

212
00:08:10,830 --> 00:08:09,490
something looks like here all this

213
00:08:12,180 --> 00:08:10,840

identical dental dead of all it goes

214
00:08:13,589 --> 00:08:12,190
down a little bit and there goes has

215
00:08:15,629 --> 00:08:13,599
this line here and then it goes soups

216
00:08:17,909 --> 00:08:15,639
down here a blow-up of this area is

217
00:08:18,779 --> 00:08:17,919
right here and you can see that it's up

218
00:08:20,279 --> 00:08:18,789
and down up and down up and down and

219
00:08:22,350 --> 00:08:20,289
then it starts to go down right about

220
00:08:23,969 --> 00:08:22,360
here so if you normalize to silicon or

221
00:08:25,560 --> 00:08:23,979
magnesium you're pumping this all up

222
00:08:27,210 --> 00:08:25,570
artificially and then you say oh it's

223
00:08:30,469 --> 00:08:27,220
enriched in little phial that's just an

224
00:08:34,170 --> 00:08:30,479
artificial product of your normalization

225
00:08:36,000 --> 00:08:34,180
okay so let's fit this line now this is

226
00:08:39,029 --> 00:08:36,010
pretty much the main result and that is

227
00:08:41,010 --> 00:08:39,039
we have here the Sun the new values of

228
00:08:42,930 --> 00:08:41,020
the Sun as I described we have here the

229
00:08:45,510 --> 00:08:42,940
bulk earth so where we really are

230
00:08:47,220 --> 00:08:45,520
comparing the proto Sun with the bulk

231
00:08:48,960 --> 00:08:47,230
earth and then we have this line here

232
00:08:51,510 --> 00:08:48,970
and what's an interesting feature is

233
00:08:53,850 --> 00:08:51,520
where does this line cross this line and

234
00:08:56,280 --> 00:08:53,860
that we spend some time to get this and

235
00:08:58,889 --> 00:08:56,290
it's 1 3 9 1 plus or minus 15 Kelvin

236
00:09:01,300 --> 00:08:58,899
here's the is to blow-up of that right

237
00:09:07,240 --> 00:09:04,179
moving along now let's compare what I

238
00:09:09,939 --> 00:09:07,250

just showed you two previous closest

239
00:09:12,910 --> 00:09:09,949
things and there are some things here

240
00:09:16,210 --> 00:09:12,920
from Carlin Lewis 93 palma no deal 2014

241
00:09:17,530 --> 00:09:16,220
mcdonough 2014 and basically they had

242
00:09:19,749 --> 00:09:17,540
this enrichment that I told you about

243
00:09:21,610 --> 00:09:19,759
when we renormalized there there's two

244
00:09:24,309 --> 00:09:21,620
aluminum for example that brings them

245
00:09:26,949 --> 00:09:24,319
all down here and then here's our 1391

246
00:09:29,290 --> 00:09:26,959
and here are their values right here so

247
00:09:31,240 --> 00:09:29,300
this would outside the error bars of our

248
00:09:33,309 --> 00:09:31,250
so we think we have the most precise

249
00:09:34,990 --> 00:09:33,319
measurement of some temperature that I

250
00:09:36,160 --> 00:09:35,000
don't think has a name I've asked lots

251
00:09:37,629 --> 00:09:36,170
of our sites what's the name of this

252
00:09:39,610 --> 00:09:37,639
temperature so we just called the D

253
00:09:41,110 --> 00:09:39,620
volatilization temperature or the brake

254
00:09:43,749 --> 00:09:41,120
temperature with a critical temperature

255
00:09:47,619 --> 00:09:43,759
beyond which you have flat here and then

256
00:09:51,970 --> 00:09:47,629
go down here now let's look now notice

257
00:09:54,040 --> 00:09:51,980
in this plot here the we have 500 is the

258
00:09:56,139 --> 00:09:54,050
lowest value of the condensation

259
00:09:58,689 --> 00:09:56,149
temperature for the next one and this is

260
00:09:59,889 --> 00:09:58,699
a log value of PC condensation

261
00:10:01,990 --> 00:09:59,899
temperature but now we're going to go

262
00:10:03,999 --> 00:10:02,000
further down and you can see that this

263
00:10:05,980 --> 00:10:04,009

balloon line which is established here

264
00:10:07,869 --> 00:10:05,990
we've just extrapolated it out here

265
00:10:09,100 --> 00:10:07,879
now one thing you could do when you

266
00:10:12,460 --> 00:10:09,110
extrapolate it out here you can say oh

267
00:10:14,530 --> 00:10:12,470
look at that this the mercury in the

268
00:10:16,689 --> 00:10:14,540
earth looks like it's over abundant

269
00:10:19,389 --> 00:10:16,699
compared to this line what could be

270
00:10:22,179 --> 00:10:19,399
wrong well what's wrong is that there is

271
00:10:24,910 --> 00:10:22,189
no measurement of photosphere of mercury

272
00:10:26,499 --> 00:10:24,920
so we just assume it's been from the sea

273
00:10:29,170 --> 00:10:26,509
ice and when you do that you get a

274
00:10:31,299 --> 00:10:29,180
miscalculation here but with you I have

275
00:10:33,340 --> 00:10:31,309
five minutes okay so if you say you know

276
00:10:35,410 --> 00:10:33,350
what let's not assume that the mercury

277
00:10:37,900 --> 00:10:35,420
this seemed like this pretty volatile

278
00:10:40,299 --> 00:10:37,910
thing is the same in CIS and the

279
00:10:42,340 --> 00:10:40,309
protosun then you get then you bring

280
00:10:45,189 --> 00:10:42,350
this down to here and you get much more

281
00:10:47,710 --> 00:10:45,199
Corden's all your in discussion time

282
00:10:51,189 --> 00:10:47,720
okay you're in the question time okay I

283
00:10:52,689 --> 00:10:51,199
will stop in about a minute I guess the

284
00:10:55,030 --> 00:10:52,699
point is that when you extrapolate here

285
00:10:56,980 --> 00:10:55,040
you get some noble gases which don't fit

286
00:10:58,780 --> 00:10:56,990
that line very well they're all depleted

287
00:11:00,910 --> 00:10:58,790
here and I we suspect that the

288
00:11:03,040 --> 00:11:00,920

condensation temperatures of oh and C

289
00:11:04,749 --> 00:11:03,050
are not right because Lauder's

290
00:11:07,150 --> 00:11:04,759
condensation temperatures are due to an

291
00:11:09,189 --> 00:11:07,160
equilibrium gas that's cooling and at

292
00:11:11,439 --> 00:11:09,199
equilibrium and I suspect we're talking

293
00:11:13,419 --> 00:11:11,449
about really non equilibrium in other

294
00:11:15,070 --> 00:11:13,429
words we have big chunks of material

295
00:11:18,730 --> 00:11:15,080
that's coming into the crease

296
00:11:20,860 --> 00:11:18,740
that is not it's not like an onion well

297
00:11:23,740 --> 00:11:20,870
it's not that equilibrium I just say

298
00:11:25,300 --> 00:11:23,750
that and it gets sublimated and what

299
00:11:27,610 --> 00:11:25,310
else I want to say and see it well

300
00:11:34,120 --> 00:11:27,620
that's they're probably different values

301
00:11:36,280 --> 00:11:34,130
for PC for Owens and C and what else so

302
00:11:38,820 --> 00:11:36,290
we also looked at this in terms of the

303
00:11:41,200 --> 00:11:38,830
CIS and we got some kind of condé

304
00:11:42,460 --> 00:11:41,210
volatilization temperature for CIS as

305
00:11:44,440 --> 00:11:42,470
you can see that they're very close to

306
00:11:46,270 --> 00:11:44,450
the Sun and then they diverge right here

307
00:11:48,160 --> 00:11:46,280
and I'm running out of time we

308
00:11:49,720 --> 00:11:48,170
recalibrated to see I just have a look

309
00:11:52,360 --> 00:11:49,730
at it from another way and we have the

310
00:11:55,660 --> 00:11:52,370
Sun going up the CIA or Moises to the

311
00:11:57,250 --> 00:11:55,670
one and then the last slide is to first

312
00:11:58,150 --> 00:11:57,260
order the earth is a dibala five pieces

313
00:12:00,400 --> 00:11:58,160

of solar nebula

314
00:12:01,780 --> 00:12:00,410
similarly rocky exoplanets are most

315
00:12:03,010 --> 00:12:01,790
certainly develop lies piece of the

316
00:12:04,870 --> 00:12:03,020
stellar net without of which they in

317
00:12:06,130 --> 00:12:04,880
their host stars form by comparing the

318
00:12:08,140 --> 00:12:06,140
compositional difference between premise

319
00:12:09,490 --> 00:12:08,150
on and earths we have quantified the

320
00:12:10,480 --> 00:12:09,500
first-order develop relation patterns

321
00:12:12,880 --> 00:12:10,490
that can be used to estimate the

322
00:12:14,470 --> 00:12:12,890
chemical composition of rock EXO planets

323
00:12:15,940 --> 00:12:14,480
around other stars because we have those

324
00:12:18,040 --> 00:12:15,950
other stars elemental abundances by

325
00:12:30,699 --> 00:12:18,050
doing spectrum thank you

326
00:12:33,939 --> 00:12:32,559
Charlie very interesting talk I

327
00:12:34,929 --> 00:12:33,949
definitely want to talk to you and get

328
00:12:37,749 --> 00:12:34,939
your slides afterwards

329
00:12:39,400 --> 00:12:37,759
um are you oh I'm sorry Carolus Johns

330
00:12:42,660 --> 00:12:39,410
Hopkins Applied Physics Laboratory old

331
00:12:45,160 --> 00:12:42,670
friends of Charlie for many years I

332
00:12:46,359 --> 00:12:45,170
would be a little worried about your gia

333
00:12:47,530 --> 00:12:46,369
volatility and temperatures you're

334
00:12:49,720 --> 00:12:47,540
assuming for carbon hydrogen oxygen

335
00:12:51,280 --> 00:12:49,730
nitrogen as you know John elements can

336
00:12:53,829 --> 00:12:51,290
combine into many different materials

337
00:12:56,019 --> 00:12:53,839
all of which have usually are vastly

338
00:12:57,220 --> 00:12:56,029

different evaporation temperatures so

339
00:12:59,169 --> 00:12:57,230
you may want to make that part of your

340
00:13:00,999 --> 00:12:59,179
problem is bulk carbon it isn't just

341
00:13:02,679 --> 00:13:01,009
both oxygen and graphic exactly I

342
00:13:04,660 --> 00:13:02,689
completely agree with you that's why we

343
00:13:07,059 --> 00:13:04,670
have these little but what we can do is

344
00:13:08,889 --> 00:13:07,069
figure out what those condensation

345
00:13:11,230 --> 00:13:08,899
temperatures are for right here for

346
00:13:13,179 --> 00:13:11,240
example we can say okay let's pretend

347
00:13:15,369 --> 00:13:13,189
that they fit what does that say about

348
00:13:17,259 --> 00:13:15,379
the different elements in a in them and

349
00:13:18,540 --> 00:13:17,269
it's a little bit like well I suspect

350
00:13:21,669 --> 00:13:18,550
that that will give more accurate

351
00:13:23,619 --> 00:13:21,679
distributions of these elements rather

352
00:13:26,559 --> 00:13:23,629
than the ones that were put in by waters

353
00:13:29,169 --> 00:13:26,569
when she did a calculation skeeved and I

354
00:13:31,119 --> 00:13:29,179
show you this is really fantastic it's a

355
00:13:33,939 --> 00:13:31,129
very much needed thing so I'm very

356
00:13:36,369 --> 00:13:33,949
excited also to get a preprint or

357
00:13:37,989 --> 00:13:36,379
something I wanted to do the same thing

358
00:13:39,519 --> 00:13:37,999
and what I ran into that for sadirah

359
00:13:41,470 --> 00:13:39,529
files they're all in the core and we

360
00:13:44,019 --> 00:13:41,480
don't know what's in the core and for

361
00:13:45,610 --> 00:13:44,029
refractories very often they actually

362
00:13:46,660 --> 00:13:45,620
just assume the abundances of the

363
00:13:47,889 --> 00:13:46,670

Santa's chondrites

364
00:13:50,259 --> 00:13:47,899
how did you get around those problems

365
00:13:51,639 --> 00:13:50,269
well one thing is the first thing we had

366
00:13:54,220 --> 00:13:51,649
to do is figure out what the mass

367
00:13:56,499 --> 00:13:54,230
fraction of the core is is there about

368
00:13:58,059 --> 00:13:56,509
four four things that the four papers

369
00:13:59,619 --> 00:13:58,069
have been written but earth scientists

370
00:14:01,809 --> 00:13:59,629
are convinced that they don't need to

371
00:14:04,480 --> 00:14:01,819
put air bars so we said oh there have

372
00:14:06,460 --> 00:14:04,490
four just we have four numbers for the

373
00:14:09,879 --> 00:14:06,470
mass fraction of the core so you need to

374
00:14:12,850 --> 00:14:09,889
know is that 32 into 33 is it 31 and we

375
00:14:14,829 --> 00:14:12,860
looked at that carefully and combined

376
00:14:16,150 --> 00:14:14,839
results and then we had to use a new

377
00:14:17,379 --> 00:14:16,160
gravitational constant too because the

378
00:14:18,730 --> 00:14:17,389
total mass of the Earth has changed

379
00:14:21,009 --> 00:14:18,740
because little big G has changed a

380
00:14:23,470 --> 00:14:21,019
little bit so these are tiny well I

381
00:14:26,110 --> 00:14:23,480
would say significant but usually

382
00:14:28,660 --> 00:14:26,120
detailed differences also you're right

383
00:14:30,280 --> 00:14:28,670
that the MOT it's model dependent but

384
00:14:31,749 --> 00:14:30,290
there are about seven models so what we

385
00:14:32,980 --> 00:14:31,759
did is say well there's a model there's

386
00:14:34,720 --> 00:14:32,990
a model there's a model for what the

387
00:14:35,949 --> 00:14:34,730
composition of the core is and then we

388
00:14:37,119 --> 00:14:35,959

just said okay let's take the upper and

389
00:14:39,189 --> 00:14:37,129
lower error bar and say that's the

390
00:14:40,509 --> 00:14:39,199
uncertainty in the composition of the

391
00:14:41,050 --> 00:14:40,519
core which we then add to the primitive

392
00:14:42,400 --> 00:14:41,060
mental

393
00:14:43,600 --> 00:14:42,410
you're right the primitive man slit

394
00:14:46,210 --> 00:14:43,610
everybody knows about it because it's

395
00:14:49,300 --> 00:14:46,220
more accessible but there are many many

396
00:14:50,830 --> 00:14:49,310
ways to model not get great estimates

397
00:14:53,050 --> 00:14:50,840
for the core but the best ones that

398
00:14:54,730 --> 00:14:53,060
exist and that's the ones we used okay

399
00:14:56,740 --> 00:14:54,740
we'll talk with error bars that are

400
00:14:58,570 --> 00:14:56,750
legitimate really reflect how much the

401
00:15:01,030 --> 00:14:58,580
people who are modeling the course think

402
00:15:02,770 --> 00:15:01,040
they know about it in other words don't

403
00:15:04,630 --> 00:15:02,780
just oh we can't do anything about it I

404
00:15:06,100 --> 00:15:04,640
think that's just uh that's what

405
00:15:07,360 --> 00:15:06,110
everybody in their sciences community

406
00:15:09,340 --> 00:15:07,370
has done so far because they don't keep

407
00:15:11,180 --> 00:15:09,350
track of their error bar let and your oh