Flux of IDP on Titan

- Calculate the mass flux of impactors from the IDP the orbital radius of Titan, with Saturn's gravitational influence considered
- Equations used from paper titled: *E Ring Dust Sources: Implications from Cassini's dust measurements - Spahn et al 2006*

$$F_{imp} = \langle m_{imp} \rangle n_{imp}(r) \langle v_{imp} \rangle (r), \quad (1)$$

1
00:00:11,590 --> 00:00:08,290
so I've been lucky enough to get the

2
00:00:14,049 --> 00:00:11,600
first talks of both sessions or maybe

3
00:00:15,220 --> 00:00:14,059
unfortunate so I'm going to talk about

4
00:00:17,589 --> 00:00:15,230
something completely different than

5
00:00:19,630 --> 00:00:17,599
Sagan talking about particle flux on

6
00:00:23,080 --> 00:00:19,640
Titan and implications for a biosphere

7
00:00:26,800 --> 00:00:23,090
and it sounds really sexy I know but

8
00:00:28,600 --> 00:00:26,810
it's not as sexy as exomoons or life on

9
00:00:30,100 --> 00:00:28,610
other planets but we're going to I'm

10
00:00:33,460 --> 00:00:30,110
going to try and make it spicy for you

11
00:00:35,560 --> 00:00:33,470
guys so let's talk about Titan maybe if

12
00:00:37,900 --> 00:00:35,570
you guys are chemist or geologists are

13
00:00:40,740 --> 00:00:37,910

not a strong planetary geologist Titan

14
00:00:44,470 --> 00:00:40,750
is not as familiar to you as it is for

15
00:00:47,500 --> 00:00:44,480
some it gets second place for being the

16
00:00:49,900 --> 00:00:47,510
largest moon it's 5,000 kilometers in

17
00:00:51,660 --> 00:00:49,910
diameter first place goes to Ganymede

18
00:00:54,029 --> 00:00:51,670
that was mentioned in the top previous

19
00:00:57,340 --> 00:00:54,039
just by a hundred kilometers so it's

20
00:00:59,439 --> 00:00:57,350
fairly comparable it's two times the

21
00:01:02,169 --> 00:00:59,449
mass of our Moon and it's bigger than

22
00:01:04,810 --> 00:01:02,179
mercury and it's actually close to the

23
00:01:07,360 --> 00:01:04,820
size of Mars it's the only moon with a

24
00:01:10,300 --> 00:01:07,370
significant atmosphere and liquid on its

25
00:01:14,429 --> 00:01:10,310
surface but it's really cold it's 180

26
00:01:18,399 --> 00:01:14,439
minus 180 degrees Celsius so here's a

27
00:01:23,230 --> 00:01:18,409
comparison our Moon and Titan so it's

28
00:01:24,969 --> 00:01:23,240
fairly big and some images of evidence

29
00:01:27,700 --> 00:01:24,979
for liquid on the surface of courses in

30
00:01:31,420 --> 00:01:27,710
liquid water at temperatures at this

31
00:01:33,550 --> 00:01:31,430
cold all water would be so cold that it

32
00:01:39,069 --> 00:01:33,560
will be hard as rock in fact the pebbles

33
00:01:41,260 --> 00:01:39,079
on Titan are actually water ice and so

34
00:01:46,840 --> 00:01:41,270
are the mountains so it's a familiar

35
00:01:48,639 --> 00:01:46,850
system yet very foreign chemically so in

36
00:01:52,510 --> 00:01:48,649
the bigger picture of the universe why

37
00:01:55,060 --> 00:01:52,520
is tightened so tasty it's known as a

38
00:01:57,789 --> 00:01:55,070

prebiotic chemical system which means it

39
00:01:59,440 --> 00:01:57,799
looks like early Earth if you guys have

40
00:02:01,919 --> 00:01:59,450
heard of the miller-urey experiment they

41
00:02:06,219 --> 00:02:01,929
did that putting similar chemicals and

42
00:02:09,160 --> 00:02:06,229
into a chamber and seeing if any amino

43
00:02:11,050 --> 00:02:09,170
acids came about well its atmosphere is

44
00:02:13,120 --> 00:02:11,060
mainly nitrogen with a little bit of

45
00:02:16,330 --> 00:02:13,130
methane so it's really similar to early

46
00:02:18,850 --> 00:02:16,340
Earth conditions and there's also a

47
00:02:19,920 --> 00:02:18,860
possible internal water ocean kind of

48
00:02:22,890 --> 00:02:19,930
similar to Europa

49
00:02:24,630 --> 00:02:22,900
a little bit smaller and they think that

50
00:02:26,399 --> 00:02:24,640
there is that because when they're

51
00:02:27,869 --> 00:02:26,409
observing it with Cassini so if you're

52
00:02:31,259 --> 00:02:27,879
not familiar with the Cassini mission

53
00:02:32,869 --> 00:02:31,269
its orbiting Saturn as we speak and it

54
00:02:36,830 --> 00:02:32,879
noticed kind of a wobble or

55
00:02:40,199 --> 00:02:36,840
inconsistency with being a solid moon

56
00:02:42,360 --> 00:02:40,209
it's rich in organics and has active

57
00:02:44,039 --> 00:02:42,370
surface geology it's also got a

58
00:02:47,220 --> 00:02:44,049
protective atmosphere which we know is

59
00:02:49,979 --> 00:02:47,230
good for life and it's inside Saturn's

60
00:02:51,869 --> 00:02:49,989
magnetosphere so it's got protection so

61
00:02:54,710 --> 00:02:51,879
it is kind of an ideal candidate and it

62
00:02:57,240 --> 00:02:54,720
perks astrobiologist ears for sure and

63
00:03:02,970 --> 00:02:57,250

here's just an image of what a possible

64
00:03:05,039 --> 00:03:02,980
internal ocean might look like oh but is

65
00:03:09,240 --> 00:03:05,049
it enough is it enough for life as we

66
00:03:13,170 --> 00:03:09,250
know it on earth so the really cool

67
00:03:14,640 --> 00:03:13,180
thing is there's a synthetic biologist

68
00:03:19,379 --> 00:03:14,650
at the University of Florida at the eff

69
00:03:23,750 --> 00:03:19,389
Fame lat laughs at the I'm not I forget

70
00:03:27,420 --> 00:03:23,760
what it stands for grass supper thanks

71
00:03:31,469 --> 00:03:27,430
and he has all these crazy theories of

72
00:03:37,339 --> 00:03:31,479
creating a type of biochemistry at these

73
00:03:39,330 --> 00:03:37,349
pressures and temperatures on Titan but

74
00:03:41,879 --> 00:03:39,340
you would need a couple of other things

75
00:03:46,199 --> 00:03:41,889
that then already exist on Titan and

76
00:03:49,110 --> 00:03:46,209
we'll go into it in just a second so

77
00:03:52,289 --> 00:03:49,120
fortunately for Titan it's being

78
00:03:56,550 --> 00:03:52,299
bombarded with a couple of extra goodies

79
00:03:59,039 --> 00:03:56,560
q so it has anyone heard of

80
00:04:00,869 --> 00:03:59,049
interplanetary dust particles it's kind

81
00:04:03,659 --> 00:04:00,879
of left over from the formation of the

82
00:04:06,179 --> 00:04:03,669
solar system just particles that are

83
00:04:09,089 --> 00:04:06,189
just floating around in our solar system

84
00:04:11,099 --> 00:04:09,099
and some reach Titan and we wanted to

85
00:04:12,569 --> 00:04:11,109
know okay what's making it to tighten if

86
00:04:14,429 --> 00:04:12,579
we want to have a biosphere there if we

87
00:04:16,710 --> 00:04:14,439
want to envision these creatures that

88
00:04:18,270 --> 00:04:16,720

could live or have metabolisms or

89
00:04:20,339 --> 00:04:18,280
biochemistry at these tempers

90
00:04:23,820 --> 00:04:20,349
temperatures and pressures what would

91
00:04:27,240 --> 00:04:23,830
you need so we want to see what's making

92
00:04:28,620 --> 00:04:27,250
it rain on Titan there's also a ring

93
00:04:32,070 --> 00:04:28,630
particles that we're going to look at

94
00:04:33,750 --> 00:04:32,080
and that's coming from an insulative so

95
00:04:35,310 --> 00:04:33,760
if here's a picture of Saturn

96
00:04:37,950 --> 00:04:35,320
and it's creating this ring called the e

97
00:04:40,830 --> 00:04:37,960
ring so the Rings are all labeled ABCD

98
00:04:42,030 --> 00:04:40,840
and the e ring is this diffuse one here

99
00:04:44,370 --> 00:04:42,040
it's a little bit different than the

100
00:04:47,190 --> 00:04:44,380
other rings and it's produced by our

101
00:04:49,890 --> 00:04:47,200
friend Enceladus so in sodus as you

102
00:04:51,690 --> 00:04:49,900
probably know has water geysers coming

103
00:04:54,960 --> 00:04:51,700
out of its South Pole or i like to call

104
00:04:59,960 --> 00:04:54,970
it the pp moon now laughing that was

105
00:05:02,670 --> 00:04:59,970
Hawaii so basically we need to calculate

106
00:05:05,190 --> 00:05:02,680
what is the flux of interplanetary dust

107
00:05:07,800 --> 00:05:05,200
particles getting to tighten and what is

108
00:05:10,410 --> 00:05:07,810
the flux of earring particles so from

109
00:05:13,170 --> 00:05:10,420
here henceforth there will be IDPs for

110
00:05:15,450 --> 00:05:13,180
interplan of desk particles and ER ps4

111
00:05:18,110 --> 00:05:15,460
earring particles and we know what's

112
00:05:20,940 --> 00:05:18,120
getting there by this really nifty

113
00:05:24,180 --> 00:05:20,950

instrument on Cassini called the CDA or

114
00:05:26,400 --> 00:05:24,190
cosmic dust analyzer and the elements

115
00:05:29,070 --> 00:05:26,410
that were interested in our germanium

116
00:05:33,000 --> 00:05:29,080
oxygen boron arsenic and molybdenum and

117
00:05:35,940 --> 00:05:33,010
we were told by dr. Steve Benner that

118
00:05:42,270 --> 00:05:35,950
these would be helpful in very cold

119
00:05:44,820 --> 00:05:42,280
biochemistry so from the e ring me back

120
00:05:46,650 --> 00:05:44,830
up so interplanetary dust particles

121
00:05:48,950 --> 00:05:46,660
we're assuming a chondritic composition

122
00:05:52,110 --> 00:05:48,960
which if you ever heard of contradict

123
00:05:54,540 --> 00:05:52,120
chondrites a meteorites it's a similar

124
00:05:56,220 --> 00:05:54,550
composition to that and the e ring

125
00:05:58,050 --> 00:05:56,230
particles are mainly water ice particles

126
00:06:03,090 --> 00:05:58,060
because they're spewing out from cryo

127
00:06:04,380 --> 00:06:03,100
volcanoes on Enceladus so now I'm going

128
00:06:05,400 --> 00:06:04,390
to throw a bunch of equations at your

129
00:06:08,220 --> 00:06:05,410
face that you don't have to pay

130
00:06:10,110 --> 00:06:08,230
attention to so basically as we're

131
00:06:12,210 --> 00:06:10,120
trying to calculate the flux on to

132
00:06:14,700 --> 00:06:12,220
tighten we have to take in to

133
00:06:16,770 --> 00:06:14,710
consideration the gravity of Saturn it

134
00:06:19,020 --> 00:06:16,780
creates a lensing effect so if I was

135
00:06:22,140 --> 00:06:19,030
shooting lasers at Saturn they would

136
00:06:25,110 --> 00:06:22,150
with of particles they would lens

137
00:06:27,630 --> 00:06:25,120
towards Saturn as you get closer and

138
00:06:30,120 --> 00:06:27,640

spread farther out and Titan is about

139
00:06:33,270 --> 00:06:30,130
the distance the Radia 21 radius of

140
00:06:36,750 --> 00:06:33,280
Saturn away from Saturn so it's pretty

141
00:06:38,760 --> 00:06:36,760
far out there and just here's the

142
00:06:46,640 --> 00:06:38,770
equations we use to calculate to model

143
00:06:52,860 --> 00:06:49,680
so once we got the flux getting to

144
00:06:54,510 --> 00:06:52,870
tighten we wanted to know first we had

145
00:06:56,760 --> 00:06:54,520
to take the cross section of it so okay

146
00:07:00,510 --> 00:06:56,770
we know the flux we have to multiply it

147
00:07:02,730 --> 00:07:00,520
by how much is actually impacting and

148
00:07:06,210 --> 00:07:02,740
then what we did was distributed over

149
00:07:09,360 --> 00:07:06,220
the entire service area so what we

150
00:07:12,420 --> 00:07:09,370
determined it was 7.5 seven times ten to

151
00:07:14,610 --> 00:07:12,430
the minus 18 grams per centimeter

152
00:07:19,440 --> 00:07:14,620
squared for a second so small very small

153
00:07:21,570 --> 00:07:19,450
numbers so not that sexy and when we're

154
00:07:23,370 --> 00:07:21,580
talking about abundance we're using a

155
00:07:26,160 --> 00:07:23,380
contradict abundance as I was mentioning

156
00:07:27,480 --> 00:07:26,170
and here's how you can look at that if

157
00:07:29,820 --> 00:07:27,490
you're looking at a periodic table

158
00:07:34,170 --> 00:07:29,830
certain elements are more abundant as

159
00:07:37,920 --> 00:07:34,180
you can see oxygen here is makes up the

160
00:07:41,010 --> 00:07:37,930
majority of math programs I know that

161
00:07:43,680 --> 00:07:41,020
sounds confusing but basically what you

162
00:07:45,630 --> 00:07:43,690
need to know is oxygen is prevalent some

163
00:07:50,520 --> 00:07:45,640

of the other elements are not as

164
00:07:53,850 --> 00:07:50,530
prevalent and when we get to flux of

165
00:07:55,950 --> 00:07:53,860
earring particles so if you look here we

166
00:07:58,320 --> 00:07:55,960
have a radius from Saturn of Saturn's

167
00:08:00,750 --> 00:07:58,330
here and go out Titans all the way over

168
00:08:03,150 --> 00:08:00,760
here but right around here around four

169
00:08:04,980 --> 00:08:03,160
radius of Saturn or radii of Saturn is

170
00:08:07,380 --> 00:08:04,990
where enceladus's so you can see the

171
00:08:09,780 --> 00:08:07,390
structure of the earring is different

172
00:08:12,480 --> 00:08:09,790
before and after in the orbit of

173
00:08:15,270 --> 00:08:12,490
Enceladus so when we go out we have to

174
00:08:20,580 --> 00:08:15,280
calculate how diffuse the earring gets

175
00:08:22,200 --> 00:08:20,590
at the orbit of Titan yeah so the next

176
00:08:24,210 --> 00:08:22,210
question is how long does it take

177
00:08:27,390 --> 00:08:24,220
particles to get from Titan to and sell

178
00:08:30,240 --> 00:08:27,400
this and it turns out they it takes

179
00:08:32,700 --> 00:08:30,250
about 300 to 500 years to get to make it

180
00:08:34,950 --> 00:08:32,710
out there so fairly large time scales or

181
00:08:38,390 --> 00:08:34,960
fairly small if you're talking about

182
00:08:41,909 --> 00:08:38,400
cosmic time and there's another bummer

183
00:08:43,950 --> 00:08:41,919
particles lose mass over time and if you

184
00:08:46,680 --> 00:08:43,960
start small there's not a good chance

185
00:08:48,120 --> 00:08:46,690
that you'll make it to tighten so you

186
00:08:50,310 --> 00:08:48,130
want to start you want to have big

187
00:08:54,420 --> 00:08:50,320
particles a big part of those have the

188
00:08:57,960 --> 00:08:54,430

best chance of making it to tighten so

189
00:08:58,670 --> 00:08:57,970
our conclusions over a billion years and

190
00:09:01,630 --> 00:08:58,680
the reason why we

191
00:09:03,530 --> 00:09:01,640
wanted to know over a billion years is

192
00:09:07,010 --> 00:09:03,540
because that's about the rate of

193
00:09:12,740 --> 00:09:07,020
resurfacing of Titan our numbers are

194
00:09:16,660 --> 00:09:12,750
fairly small as you can see this is over

195
00:09:18,980 --> 00:09:16,670
50 kilometer crust so as the surface

196
00:09:22,010 --> 00:09:18,990
resurfaces itself it will distribute

197
00:09:24,410 --> 00:09:22,020
about 50 kilometers down roughly so I

198
00:09:26,210 --> 00:09:24,420
wanted to see how much mass and how much

199
00:09:27,740 --> 00:09:26,220
of this flux is actually making it down

200
00:09:29,900 --> 00:09:27,750
and how much flux of those specific

201
00:09:33,380 --> 00:09:29,910
elements we were looking at so very

202
00:09:35,120 --> 00:09:33,390
small numbers 10 to the minus 15 grams

203
00:09:39,790 --> 00:09:35,130
per centimeter squared in the case of

204
00:09:43,639 --> 00:09:39,800
molybdenum how am I on time by the way

205
00:09:46,940 --> 00:09:43,649
ok cool so I think I'll actually went

206
00:09:48,769 --> 00:09:46,950
too fast I had like 20 slides so epid

207
00:09:50,860 --> 00:09:48,779
basically what I wanted you to get out

208
00:09:52,970 --> 00:09:50,870
of this is at the distance of Titan

209
00:09:54,860 --> 00:09:52,980
interplanetary dust particles are more

210
00:09:56,720 --> 00:09:54,870
dominant than earring particles which is

211
00:09:59,120 --> 00:09:56,730
kind of counterintuitive so you would

212
00:10:01,400 --> 00:09:59,130
think that earring particles would would

213
00:10:03,079 --> 00:10:01,410

populate Titan more but because of the

214
00:10:06,470 --> 00:10:03,089
nature of the ring and how it diffuses

215
00:10:08,690 --> 00:10:06,480
past Enceladus turns out earring

216
00:10:12,199 --> 00:10:08,700
particles are dominant by an order of

217
00:10:15,920 --> 00:10:12,209
magnitude and the other conclusion is

218
00:10:18,710 --> 00:10:15,930
not incredibly promising for a potential

219
00:10:21,920 --> 00:10:18,720
biosphere and I wish I had better news

220
00:10:25,010 --> 00:10:21,930
for you but but it still it provides an

221
00:10:27,460 --> 00:10:25,020
interesting case if we're looking at

222
00:10:31,100 --> 00:10:27,470
other solar systems if we're looking

223
00:10:34,220 --> 00:10:31,110
excuse me XO system XO solar systems and

224
00:10:37,130 --> 00:10:34,230
we're trying to see if there is possible

225
00:10:39,560 --> 00:10:37,140
nutrients for exotic forms of life in

226
00:10:46,130 --> 00:10:39,570
different parts of the solar system this

227
00:10:47,900 --> 00:10:46,140
is a good model to use an ongoing in

228
00:10:50,360 --> 00:10:47,910
future studies we want to look more into

229
00:10:53,060 --> 00:10:50,370
cratering rates and see how that affects

230
00:10:57,230 --> 00:10:53,070
and resurfaces titan and different

231
00:11:00,079 --> 00:10:57,240
surface processes and how the abundance

232
00:11:03,079 --> 00:11:00,089
works its way through the crust and the

233
00:11:05,380 --> 00:11:03,089
implications for life and I know I

234
00:11:08,390 --> 00:11:05,390
probably went a little bit too fast

235
00:11:18,590 --> 00:11:08,400
perfect okay so I'll take any questions

236
00:11:25,200 --> 00:11:21,860
did you consider the extra focusing from

237
00:11:28,320 --> 00:11:25,210
Titan itself yeah that was factored into

238
00:11:31,290 --> 00:11:28,330

it as well but it's a lot less yeah I'm

239
00:11:35,220 --> 00:11:31,300
Saturn and actually we had to we rent

240
00:11:39,600 --> 00:11:35,230
two different is everything good okay so

241
00:11:42,360 --> 00:11:39,610
we actually did too I guess models of it

242
00:11:44,220 --> 00:11:42,370
once we won we use just equations to see

243
00:11:46,519 --> 00:11:44,230
what theoretically should be getting to

244
00:11:50,400 --> 00:11:46,529
tighten and then we just actually used

245
00:11:52,980 --> 00:11:50,410
cosmic dust analyzer data and for

246
00:11:56,790 --> 00:11:52,990
whatever reason the actual data was an

247
00:12:04,380 --> 00:11:56,800
order of magnitude lower than what the

248
00:12:06,780 --> 00:12:04,390
model showed us say what yeah yeah

249
00:12:09,600 --> 00:12:06,790
that's true you have a question from

250
00:12:11,790 --> 00:12:09,610
online San Jose asking how does one

251
00:12:15,900 --> 00:12:11,800
determine the race theory surfacing rate

252
00:12:21,050 --> 00:12:15,910
of Titan infrared from craters yeah

253
00:12:30,960 --> 00:12:23,100
that's about all I know what to be

254
00:12:33,360 --> 00:12:30,970
honest have you looked at the particle

255
00:12:37,620 --> 00:12:33,370
flux from the earring on Enceladus

256
00:12:39,900 --> 00:12:37,630
itself we have enough but they're one of

257
00:12:46,620 --> 00:12:39,910
the equations that we use how do I go

258
00:12:48,630 --> 00:12:46,630
back so we took those big fancy

259
00:12:51,269 --> 00:12:48,640
equations i showed you from a paper by

260
00:12:54,090 --> 00:12:51,279
spawn at all in 2006 and that actually

261
00:12:57,769 --> 00:12:54,100
was from from cratering rates or

262
00:13:00,240 --> 00:12:57,779
impactor rates on of the other moons so

263
00:13:07,930 --> 00:13:00,250

that's I think that has been done but we

264
00:13:12,740 --> 00:13:11,030
yeah no I actually did look at that when

265
00:13:15,050 --> 00:13:12,750
the follow up in a follow-up paper and

266
00:13:18,200 --> 00:13:15,060
the actually the kinetic energy flux

267
00:13:19,670 --> 00:13:18,210
from the idea from IDPs is higher on and

268
00:13:21,050 --> 00:13:19,680
selda Stan from the e ring particles

269
00:13:23,840 --> 00:13:21,060
because the ring particles have zero

270
00:13:25,310 --> 00:13:23,850
velocity relative to ten syllabus so

271
00:13:28,460 --> 00:13:25,320
that most of you most of the dust

272
00:13:30,800 --> 00:13:28,470
impacts on its oldest are earring stuff