KROME

better science through chemistry

- Python pre-processor provides Fortran routines
- Creates modules from chemical network
- Dust evolution, cooling heating photoionization
- Large test suite
- Highly optimized, fast solvers
- Open source, bitbucket community
- Grassi T. et al., MNRAS 2014. doi:10.1093/mnras/stu114

www.kromepackage.org

1
00:00:11,650 --> 00:00:09,040
so thanks a lot thanks Daniel for

2
00:00:13,570 --> 00:00:11,660
introducing me and really glad to be

3
00:00:17,019 --> 00:00:13,580
here for the second year to the a black

4
00:00:18,429 --> 00:00:17,029
one so yeah I will present you I really

5
00:00:20,859 --> 00:00:18,439
introduce your son something about

6
00:00:22,810 --> 00:00:20,869
chemical disequilibrium and how we can

7
00:00:24,790 --> 00:00:22,820
use chemical disequilibrium to assess

8
00:00:31,450 --> 00:00:24,800
about a bit ability of planetary

9
00:00:33,549 --> 00:00:31,460
atmosphere so yeah after okay after a

10
00:00:36,040 --> 00:00:33,559
short introduction about chemical

11
00:00:37,870 --> 00:00:36,050
disequilibrium will try to discuss

12
00:00:39,490 --> 00:00:37,880
review which which are the ways to

13
00:00:41,260 --> 00:00:39,500

calculate their to calculate the

14
00:00:43,120 --> 00:00:41,270
disequilibrium actually in a chemical

15
00:00:45,670 --> 00:00:43,130
network discovering a planetary

16
00:00:47,920 --> 00:00:45,680
atmosphere and then we move on on the

17
00:00:50,530 --> 00:00:47,930
first results about the modeling of

18
00:00:53,380 --> 00:00:50,540
Earth and Mars atmosphere and which is

19
00:01:03,760 --> 00:00:53,390
the link between chemical disequilibrium

20
00:01:06,550 --> 00:01:03,770
hand a bit ability so okay so actually

21
00:01:09,460 --> 00:01:06,560
time gave a very very interesting very

22
00:01:12,700 --> 00:01:09,470
well done introduction about the sense

23
00:01:17,380 --> 00:01:12,710
the meaning of using a kind of more

24
00:01:20,770 --> 00:01:17,390
general Abbott ability tool instead

25
00:01:23,440 --> 00:01:20,780
using something to link to link to will

26
00:01:25,450 --> 00:01:23,450
too much related to human visit life so

27
00:01:28,210 --> 00:01:25,460
the life we know on the hurt of course

28
00:01:31,330 --> 00:01:28,220
hurt is the only inhabited planet we

29
00:01:34,000 --> 00:01:31,340
know at the point at this point but

30
00:01:36,820 --> 00:01:34,010
there are some mistakes that very simple

31
00:01:38,980 --> 00:01:36,830
to to make very easy to make for us so

32
00:01:42,460 --> 00:01:38,990
first of all is something that will be

33
00:01:45,100 --> 00:01:42,470
discussed just after metal is the effort

34
00:01:48,789 --> 00:01:45,110
of is the importance of some molecules

35
00:01:50,490 --> 00:01:48,799
like oxygen water ozone methane that we

36
00:01:52,899 --> 00:01:50,500
say okay if we found these kind of

37
00:01:55,300 --> 00:01:52,909
molecules in the spectra of a planet

38
00:01:57,730 --> 00:01:55,310

exoplanet we can maybe say that okay

39
00:02:01,120 --> 00:01:57,740
maybe there is something related to lie

40
00:02:04,480 --> 00:02:01,130
for some related processes similar to

41
00:02:07,030 --> 00:02:04,490
life but is not the right divide way to

42
00:02:09,279 --> 00:02:07,040
understand the problem actually oxygen

43
00:02:12,920 --> 00:02:09,289
and awesome for example can be produced

44
00:02:15,199 --> 00:02:12,930
by photochemistry in the hurtin another

45
00:02:17,569 --> 00:02:15,209
it's also not rocky planets for

46
00:02:20,420 --> 00:02:17,579
Jupiter's for example Mars and Venus you

47
00:02:23,509 --> 00:02:20,430
can find oxygen molecular oxygen we can

48
00:02:26,330 --> 00:02:23,519
find Odin reduce it by photochemistry on

49
00:02:28,699 --> 00:02:26,340
the other hand you can have a strong

50
00:02:31,940 --> 00:02:28,709
chemical disequilibrium due to other

51
00:02:35,030 --> 00:02:31,950
physical processes like fast vertical

52
00:02:38,030 --> 00:02:35,040
mixing in hot Jupiters so actually I

53
00:02:41,059 --> 00:02:38,040
visit my research on the work given by

54
00:02:44,679 --> 00:02:41,069
gene LeBell lock in the 60s and 70s that

55
00:02:46,849 --> 00:02:44,689
is try to measure to calculate the day

56
00:02:48,679 --> 00:02:46,859
entropy production that is the

57
00:02:51,409 --> 00:02:48,689
disequilibrium chemical disequilibrium

58
00:02:52,879 --> 00:02:51,419
in a planetary atmosphere and this can

59
00:02:55,309 --> 00:02:52,889
be linked it to the presence of life

60
00:02:58,490 --> 00:02:55,319
cause it is not only the presence of

61
00:02:59,809 --> 00:02:58,500
oxygen in an atmosphere doctors for

62
00:03:02,360 --> 00:02:59,819
example in the Harappan sphere that

63
00:03:04,399 --> 00:03:02,370

there's a link with life but is the

64
00:03:07,909 --> 00:03:04,409
contemporaneous presence and you can see

65
00:03:10,610 --> 00:03:07,919
here this is this is the heard some of

66
00:03:14,170 --> 00:03:10,620
the herd atmosphere was an earth

67
00:03:16,819 --> 00:03:14,180
atmosphere diagram this is an inert

68
00:03:19,280 --> 00:03:16,829
diagram of the atmosphere concentrations

69
00:03:23,059 --> 00:03:19,290
so the main point is the contemporaneous

70
00:03:25,699 --> 00:03:23,069
presence of oxygen and mitten co2 and

71
00:03:28,789 --> 00:03:25,709
methane on the her in a certain I amount

72
00:03:30,800 --> 00:03:28,799
because usually if you put together in

73
00:03:32,569 --> 00:03:30,810
the conditions describing the present

74
00:03:35,929 --> 00:03:32,579
earth if you put together oxygen and

75
00:03:38,449 --> 00:03:35,939
mitten they should wrap and the final

76
00:03:40,339 --> 00:03:38,459
equilibrium concentration of the two

77
00:03:43,580 --> 00:03:40,349
would be totally different from the

78
00:03:46,009 --> 00:03:43,590
presence one present ones so actually no

79
00:03:48,319 --> 00:03:46,019
meeting should be present on the on the

80
00:03:49,460 --> 00:03:48,329
herd right at the moment so this is due

81
00:03:53,689 --> 00:03:49,470
to the fact that there are many

82
00:03:56,809 --> 00:03:53,699
processes that are pumping new molecules

83
00:03:59,089 --> 00:03:56,819
in the atmosphere mainly they are on the

84
00:04:00,949 --> 00:03:59,099
hurt their biological processes but of

85
00:04:04,699 --> 00:04:00,959
course they are also as I said other

86
00:04:07,749 --> 00:04:04,709
processes so they mean him from this

87
00:04:10,460 --> 00:04:07,759
part of my of my job was to try to

88
00:04:12,890 --> 00:04:10,470

uncouple the different processes and try

89
00:04:15,499 --> 00:04:12,900
to give the right thermodynamic

90
00:04:19,370 --> 00:04:15,509
importance of the different topics a

91
00:04:23,390 --> 00:04:19,380
different process so how to do that I

92
00:04:24,960 --> 00:04:23,400
have to briefly try to explain which is

93
00:04:27,150 --> 00:04:24,970
the way we calculate

94
00:04:29,340 --> 00:04:27,160
we compute the disequilibrium in a

95
00:04:33,840 --> 00:04:29,350
chemical network discovery and planetary

96
00:04:36,510 --> 00:04:33,850
atmosphere so first of all to measure to

97
00:04:38,910 --> 00:04:36,520
calculate the extent of disequilibrium

98
00:04:40,770 --> 00:04:38,920
we need to deal with irreversibility of

99
00:04:43,430 --> 00:04:40,780
a system to deal with the

100
00:04:48,360 --> 00:04:43,440
irreversibility of a system we must use

101
00:04:51,720 --> 00:04:48,370
the production of entropy inside this

102
00:04:56,190 --> 00:04:51,730
system the system boundaries so to be

103
00:04:59,190 --> 00:04:56,200
just much more practical we have to deal

104
00:05:02,190 --> 00:04:59,200
with the forward and backward rates of

105
00:05:05,040 --> 00:05:02,200
each chemical chemical reaction in the

106
00:05:07,050 --> 00:05:05,050
in depth atmosphere we have to integrate

107
00:05:09,680 --> 00:05:07,060
the entropy production using this

108
00:05:12,450 --> 00:05:09,690
formulation we have the gas constant

109
00:05:14,400 --> 00:05:12,460
you're here we have the forward and

110
00:05:17,460 --> 00:05:14,410
backward rate we have to integrate this

111
00:05:19,620 --> 00:05:17,470
formulation all over the time step we

112
00:05:21,450 --> 00:05:19,630
want to measure this for a planetary

113
00:05:22,980 --> 00:05:21,460

atmosphere so we have to deal with

114
00:05:30,240 --> 00:05:22,990
something that is changing during time

115
00:05:32,159 --> 00:05:30,250
so with kinetics okay and so if you have

116
00:05:33,900 --> 00:05:32,169
any question about this I can speak

117
00:05:37,170 --> 00:05:33,910
about this a bit a bit modest about

118
00:05:41,250 --> 00:05:37,180
quite complex but you can trust me and

119
00:05:44,460 --> 00:05:41,260
this is the this is our we start from

120
00:05:46,200 --> 00:05:44,470
the theoretical thermodynamics and we we

121
00:05:48,180 --> 00:05:46,210
go to the practical calculation of

122
00:05:50,070 --> 00:05:48,190
entropy production for each chemical

123
00:05:54,570 --> 00:05:50,080
reaction then we have to sum up together

124
00:05:57,840 --> 00:05:54,580
okay so the results the application we

125
00:06:00,780 --> 00:05:57,850
are getting at the moment so first of

126
00:06:03,810 --> 00:06:00,790
all to have this theory applied to the

127
00:06:06,150 --> 00:06:03,820
chemical models we had to develop a

128
00:06:11,219 --> 00:06:06,160
totally new a package to run the

129
00:06:15,719 --> 00:06:11,229
kinetics of the huge number reactions so

130
00:06:17,490 --> 00:06:15,729
we go from a few tens to and thousands

131
00:06:19,710 --> 00:06:17,500
of chemical reactions happening Oh

132
00:06:21,750 --> 00:06:19,720
together so we had to to solve their all

133
00:06:24,270 --> 00:06:21,760
these ordinary differential equations or

134
00:06:25,890 --> 00:06:24,280
together the same moment and try to find

135
00:06:30,570 --> 00:06:25,900
out to integrate the kinetics of the

136
00:06:32,700 --> 00:06:30,580
wedge so this is you because the the

137
00:06:34,740 --> 00:06:32,710
question I showed before must be a

138
00:06:36,510 --> 00:06:34,750

standard in this way so we have to deal

139
00:06:37,150 --> 00:06:36,520
with concentrations that are changing

140
00:06:39,850 --> 00:06:37,160
doing

141
00:06:41,770 --> 00:06:39,860
okay we are not taking considering the

142
00:06:44,380 --> 00:06:41,780
atmosphere in a steady state you are

143
00:06:48,730 --> 00:06:44,390
taking the the atmosphere like a box

144
00:06:55,120 --> 00:06:48,740
reactor and living this relaxing to the

145
00:06:57,180 --> 00:06:55,130
one that each twist real chemical

146
00:07:01,120 --> 00:06:57,190
equilibrium state ok so the

147
00:07:03,940 --> 00:07:01,130
concentrations will change so we develop

148
00:07:06,400 --> 00:07:03,950
at this chrome package that is a free

149
00:07:08,950 --> 00:07:06,410
freeware package you can download from

150
00:07:12,270 --> 00:07:08,960
this website we already published

151
00:07:14,920 --> 00:07:12,280
something about that and is a very

152
00:07:17,560 --> 00:07:14,930
useful package for every kind of

153
00:07:20,770 --> 00:07:17,570
simulation kinetic simulation in the

154
00:07:22,990 --> 00:07:20,780
fields of astrophysics and planetary

155
00:07:25,690 --> 00:07:23,000
atmosphere so it can be used for other

156
00:07:27,850 --> 00:07:25,700
as the physical processes and from my

157
00:07:31,390 --> 00:07:27,860
side i am using for planetary atmosphere

158
00:07:33,640 --> 00:07:31,400
so it is able to cobble together the

159
00:07:36,460 --> 00:07:33,650
chemistry and other physical processes

160
00:07:39,730 --> 00:07:36,470
as i said so also the fusion in the case

161
00:07:42,460 --> 00:07:39,740
of planetary atmospheres so in order to

162
00:07:45,400 --> 00:07:42,470
have very correct modeling of an

163
00:07:50,620 --> 00:07:45,410

atmosphere so the first application i

164
00:07:53,710 --> 00:07:50,630
did was about using a one of the most

165
00:07:57,610 --> 00:07:53,720
used chemical network for the present

166
00:08:00,400 --> 00:07:57,620
atmosphere acylated casting 80 model is

167
00:08:02,920 --> 00:08:00,410
a column model so one dimensional model

168
00:08:07,180 --> 00:08:02,930
this is the first step we do and there

169
00:08:10,540 --> 00:08:07,190
is a 64 layer with about 80 directions

170
00:08:12,370 --> 00:08:10,550
okay thermal reaction 10 mo chemical

171
00:08:15,310 --> 00:08:12,380
reactions and photochemical reactions

172
00:08:17,770 --> 00:08:15,320
and then their results i'm going to show

173
00:08:20,560 --> 00:08:17,780
you are nothing entropy production terms

174
00:08:23,590 --> 00:08:20,570
but in something more easy ways power

175
00:08:26,920 --> 00:08:23,600
dissipation / the surface of the heads

176
00:08:28,690 --> 00:08:26,930
of per square meter and then one

177
00:08:31,930 --> 00:08:28,700
important player to say that the

178
00:08:34,570 --> 00:08:31,940
diffusion of this model is working for

179
00:08:37,540 --> 00:08:34,580
very short time steps but when we try to

180
00:08:39,550 --> 00:08:37,550
model for a long time the eddy diffusion

181
00:08:41,920 --> 00:08:39,560
actually it doesn't work so we are

182
00:08:44,620 --> 00:08:41,930
developing a much more complex but

183
00:08:45,930 --> 00:08:44,630
actually much more usable Eddie

184
00:08:49,320 --> 00:08:45,940
diffusion

185
00:08:51,780 --> 00:08:49,330
emulation for the hell yeah and as I

186
00:08:54,540 --> 00:08:51,790
said before in order to uncouple the

187
00:08:57,480 --> 00:08:54,550
different efforts of the different

188
00:08:59,850 --> 00:08:57,490

processes on the atmosphere we developed

189
00:09:03,000 --> 00:08:59,860
with developer we run the model with in

190
00:09:05,640 --> 00:09:03,010
different ways different rounds we

191
00:09:07,560 --> 00:09:05,650
revolve photochemistry we then without

192
00:09:10,890 --> 00:09:07,570
ed diffusion between the layers and

193
00:09:15,060 --> 00:09:10,900
trying to model also pray photosynthetic

194
00:09:17,160 --> 00:09:15,070
a kind of a photosynthetic heard this it

195
00:09:20,100 --> 00:09:17,170
was done these two runs were done

196
00:09:24,120 --> 00:09:20,110
because because if you think about photo

197
00:09:27,630 --> 00:09:24,130
chemistry is photo are chemical

198
00:09:30,930 --> 00:09:27,640
reactions using actually water molecule

199
00:09:34,350 --> 00:09:30,940
see 02 02 03 so molecules that are

200
00:09:38,010 --> 00:09:34,360
somehow related also to to life so we

201
00:09:39,930 --> 00:09:38,020
cannot switch off photochemistry without

202
00:09:41,760 --> 00:09:39,940
considering the habit of life on the

203
00:09:44,370 --> 00:09:41,770
photochemistry itself so we try to

204
00:09:47,340 --> 00:09:44,380
uncouple the processes in this way and

205
00:09:49,350 --> 00:09:47,350
then we also can model the Sufi fluxes

206
00:09:51,300 --> 00:09:49,360
that of the present earth that are

207
00:09:53,880 --> 00:09:51,310
maintaining the hearth far from

208
00:09:55,920 --> 00:09:53,890
equilibrium and in these ones I'm not

209
00:09:58,560 --> 00:09:55,930
considering the surface fluxes because

210
00:10:01,410 --> 00:09:58,570
as i said i am considering the hurt as a

211
00:10:04,320 --> 00:10:01,420
closet box i only have photochemistry

212
00:10:07,230 --> 00:10:04,330
for the runs that i have and i leave the

213
00:10:10,980 --> 00:10:07,240

hurt atmosphere going relaxing to

214
00:10:14,010 --> 00:10:10,990
another steady state so this is one of

215
00:10:17,460 --> 00:10:14,020
the first result this is the behavior of

216
00:10:20,790 --> 00:10:17,470
a 0 h molecule during time here at

217
00:10:24,900 --> 00:10:20,800
second so actually this run was long

218
00:10:26,940 --> 00:10:24,910
about five four billion years and then

219
00:10:29,460 --> 00:10:26,950
here you have the eight in meters and

220
00:10:31,560 --> 00:10:29,470
the concentration in color scale so you

221
00:10:35,370 --> 00:10:31,570
can see that this is actually the effort

222
00:10:37,350 --> 00:10:35,380
of the chrome model we can develop we

223
00:10:39,440 --> 00:10:37,360
can see the development they change in

224
00:10:41,640 --> 00:10:39,450
the concentration of different reference

225
00:10:45,030 --> 00:10:41,650
considering all the chemical network

226
00:10:46,950 --> 00:10:45,040
together okay but this is on the other

227
00:10:51,360 --> 00:10:46,960
side this is the results in power

228
00:10:54,570 --> 00:10:51,370
dissipation unit okay again considering

229
00:10:57,840 --> 00:10:54,580
four billion years so actually you can

230
00:10:59,100 --> 00:10:57,850
see that the system is quite stratified

231
00:11:01,079 --> 00:10:59,110
literate

232
00:11:03,750 --> 00:11:01,089
and you can see different the different

233
00:11:06,449 --> 00:11:03,760
effort of the different reactions the

234
00:11:09,630 --> 00:11:06,459
tears that have different kinetics at

235
00:11:12,000 --> 00:11:09,640
different age given a different sort of

236
00:11:14,460 --> 00:11:12,010
behavior a different age actually we can

237
00:11:17,460 --> 00:11:14,470
say as a preliminary results that of

238
00:11:20,040 --> 00:11:17,470

course we somehow expected is that the

239
00:11:21,630 --> 00:11:20,050
ozone layer has a very important role in

240
00:11:24,449 --> 00:11:21,640
the entropy production of the earth

241
00:11:27,569 --> 00:11:24,459
austria so in the disequilibrium of hurt

242
00:11:30,780 --> 00:11:27,579
atmosphere but ok don't consider the

243
00:11:33,269 --> 00:11:30,790
units because this is just to compare

244
00:11:35,009 --> 00:11:33,279
the different ones here again we have

245
00:11:38,819 --> 00:11:35,019
the time here we have four different

246
00:11:41,519 --> 00:11:38,829
rounds with and without editing sorry

247
00:11:44,490 --> 00:11:41,529
we've been without photochemistry for

248
00:11:47,370 --> 00:11:44,500
the present her run and for the hurley

249
00:11:50,160 --> 00:11:47,380
hurt run this Early Head was I mean I

250
00:11:53,069 --> 00:11:50,170
meant our kind of prey photosynthetic

251
00:11:55,380 --> 00:11:53,079
earth so in this pre photosynthetic

252
00:11:58,650 --> 00:11:55,390
heard we have quite no oxygen no

253
00:12:01,769 --> 00:11:58,660
molecular oxygen no ozone and I amount

254
00:12:04,800 --> 00:12:01,779
of co2 like maths Samar so you can see

255
00:12:08,130 --> 00:12:04,810
the effort of photochemistry if you if

256
00:12:10,350 --> 00:12:08,140
you don't have photochemistry if you

257
00:12:14,250 --> 00:12:10,360
don't have photochemistry the atmosphere

258
00:12:17,340 --> 00:12:14,260
is entropy production is differently

259
00:12:20,670 --> 00:12:17,350
layered but if you don't have life of

260
00:12:24,329 --> 00:12:20,680
photosynthetic life actually the IR

261
00:12:27,530 --> 00:12:24,339
amount of entropy is producer up in the

262
00:12:29,400 --> 00:12:27,540
atmosphere that is kind something very

263
00:12:32,519 --> 00:12:29,410

straightforward to understand because it

264
00:12:34,769 --> 00:12:32,529
this is you just 42 photochemistry so we

265
00:12:36,960 --> 00:12:34,779
have both in the present early hope we

266
00:12:38,490 --> 00:12:36,970
have both photochemistry but they have

267
00:12:40,350 --> 00:12:38,500
at the photochemistry is quite different

268
00:12:43,050 --> 00:12:40,360
due to the presence of rotation

269
00:12:44,850 --> 00:12:43,060
photosynthetic life that is taking a

270
00:12:48,870 --> 00:12:44,860
reusing the molecules to make other

271
00:12:52,560 --> 00:12:48,880
processes like biomass production so

272
00:12:55,829 --> 00:12:52,570
okay we spoke about hurt but ok we know

273
00:12:58,759 --> 00:12:55,839
her but when we have a brother of planet

274
00:13:01,319 --> 00:12:58,769
next to us about which we know something

275
00:13:04,050 --> 00:13:01,329
quite enough about the atmospheric

276
00:13:07,050 --> 00:13:04,060
composition atmospheric behavior so I

277
00:13:10,380 --> 00:13:07,060
considered Mars atmosphere as a

278
00:13:13,810 --> 00:13:10,390
comparison with The Hurt atmosphere

279
00:13:17,050 --> 00:13:13,820
entropy production so this is the model

280
00:13:20,170 --> 00:13:17,060
I consider it again I'm not considering

281
00:13:21,820 --> 00:13:20,180
here ed diffusion because what is too

282
00:13:23,800 --> 00:13:21,830
difficult to model this at the moment

283
00:13:28,720 --> 00:13:23,810
and to copper with entropy production

284
00:13:32,170 --> 00:13:28,730
and using the same units this is the

285
00:13:35,740 --> 00:13:32,180
actual result of the comparison this is

286
00:13:38,560 --> 00:13:35,750
the I'm sorry you can see is a vat per

287
00:13:40,240 --> 00:13:38,570
square meter so a free energy

288
00:13:42,160 --> 00:13:40,250

dissipation per square meter of the

289
00:13:43,960 --> 00:13:42,170
planet this is the only way to compare

290
00:13:45,820 --> 00:13:43,970
this to different planets because the

291
00:13:48,010 --> 00:13:45,830
surface of the two planets is different

292
00:13:50,260 --> 00:13:48,020
and then here we have the two rounds of

293
00:13:52,180 --> 00:13:50,270
about the present earth to rant about

294
00:13:54,850 --> 00:13:52,190
the Holy hurt and two runs about maths

295
00:13:57,460 --> 00:13:54,860
with without photochemistry that the

296
00:14:00,810 --> 00:13:57,470
main result is a result is that the

297
00:14:04,420 --> 00:14:00,820
effort of photochemistry is stronger in

298
00:14:07,570 --> 00:14:04,430
not inhabited planets like prey

299
00:14:10,600 --> 00:14:07,580
photosynthetic Earth and Mars then on

300
00:14:15,190 --> 00:14:10,610
the inhabited planet this means that

301
00:14:18,040 --> 00:14:15,200
life is reusing the free gain the free

302
00:14:20,860 --> 00:14:18,050
energy not use it yet by the

303
00:14:24,030 --> 00:14:20,870
photosynthesis sorry the photochemistry

304
00:14:27,040 --> 00:14:24,040
and use it by to photosynthesis so

305
00:14:30,160 --> 00:14:27,050
actually this means that when you will

306
00:14:32,350 --> 00:14:30,170
see a planet with a very strong very

307
00:14:34,780 --> 00:14:32,360
strong disequilibrium due to

308
00:14:37,270 --> 00:14:34,790
photochemical reaction then you can say

309
00:14:39,400 --> 00:14:37,280
if you run the model of the same plan

310
00:14:42,460 --> 00:14:39,410
without photochemistry and the

311
00:14:45,040 --> 00:14:42,470
difference is 2 is very huge with the

312
00:14:47,770 --> 00:14:45,050
compared to the experimental data so the

313
00:14:51,280 --> 00:14:47,780

data you see with the spectra of Sabbath

314
00:14:54,010 --> 00:14:51,290
spectra then we can say that it's very

315
00:14:56,530 --> 00:14:54,020
difficult to death in that planet we can

316
00:14:59,200 --> 00:14:56,540
find some kind of life or some kind of

317
00:15:01,150 --> 00:14:59,210
very complex processes that can be

318
00:15:03,760 --> 00:15:01,160
compared to life but on the other hand

319
00:15:06,160 --> 00:15:03,770
if you random models within revolve

320
00:15:08,710 --> 00:15:06,170
photochemistry of the dead planet view

321
00:15:10,960 --> 00:15:08,720
of server and the models are quite

322
00:15:14,380 --> 00:15:10,970
similar down there is a a kind of very

323
00:15:15,970 --> 00:15:14,390
complex process that can be life but

324
00:15:17,680 --> 00:15:15,980
also can be something else we don't know

325
00:15:21,580 --> 00:15:17,690
that can

326
00:15:25,360 --> 00:15:21,590
that is using this dissipative free

327
00:15:27,370 --> 00:15:25,370
energy so actually we were able and we

328
00:15:29,170 --> 00:15:27,380
are able to uncouple the headset of

329
00:15:33,460 --> 00:15:29,180
photochemistry and a short of life at

330
00:15:36,790 --> 00:15:33,470
the moment just to show you just keep

331
00:15:39,490 --> 00:15:36,800
that go here this is a kind of table

332
00:15:42,820 --> 00:15:39,500
about the power dissipation of the herd

333
00:15:45,850 --> 00:15:42,830
given by how that works so if you if you

334
00:15:48,700 --> 00:15:45,860
see that the result due to other

335
00:15:52,000 --> 00:15:48,710
physical processes happening in our

336
00:15:56,130 --> 00:15:52,010
heart and our atmosphere I love the

337
00:15:58,960 --> 00:15:56,140
orders of some units too few hundreds of

338
00:16:01,870 --> 00:15:58,970

bad per square meters so that are

339
00:16:03,670 --> 00:16:01,880
comparable to the ones given here but by

340
00:16:06,880 --> 00:16:03,680
the chemistry but they are really

341
00:16:10,840 --> 00:16:06,890
they're really really eager than the one

342
00:16:13,180 --> 00:16:10,850
the ones happening on Mars okay so one

343
00:16:15,910 --> 00:16:13,190
other result is that the mats atmosphere

344
00:16:19,000 --> 00:16:15,920
is already totally different than the

345
00:16:23,530 --> 00:16:19,010
hurt one okay also if we divide the

346
00:16:26,740 --> 00:16:23,540
effort to do to the suface extension so

347
00:16:29,620 --> 00:16:26,750
just running to the observable we can

348
00:16:34,690 --> 00:16:29,630
produce into with my model so actually

349
00:16:39,730 --> 00:16:34,700
we're using some codes that daniel said

350
00:16:42,490 --> 00:16:39,740
before me some radiative transfer codes

351
00:16:45,010 --> 00:16:42,500
we can take the results of the chemical

352
00:16:47,770 --> 00:16:45,020
modeling and translating spectral we can

353
00:16:49,240 --> 00:16:47,780
observe so here I am comparing comparing

354
00:16:51,730 --> 00:16:49,250
the specter of the present verb and

355
00:16:54,940 --> 00:16:51,740
episode will be heard so the idea is

356
00:16:58,960 --> 00:16:54,950
that you know as a perspective we will

357
00:17:01,570 --> 00:16:58,970
be able to link the disequilibrium ID of

358
00:17:03,640 --> 00:17:01,580
each different model to the synthetics

359
00:17:05,230 --> 00:17:03,650
Petra and then we can compare this in we

360
00:17:08,410 --> 00:17:05,240
will be able to compare the sip that is

361
00:17:11,890 --> 00:17:08,420
Petra with the adverts Petra observe

362
00:17:14,350 --> 00:17:11,900
that of an exoplanet and from this from

363
00:17:16,300 --> 00:17:14,360

the conditions of the exoplanet we can

364
00:17:20,199 --> 00:17:16,310
somehow say something about the real

365
00:17:24,699 --> 00:17:20,209
disequilibrium of the planet compared to

366
00:17:26,740 --> 00:17:24,709
the expected one okay so yeah this is

367
00:17:28,780 --> 00:17:26,750
just about the perspectives actually we

368
00:17:30,490 --> 00:17:28,790
we are developing new

369
00:17:31,720 --> 00:17:30,500
new parts of the model we are

370
00:17:33,940 --> 00:17:31,730
considering the change in the

371
00:17:36,340 --> 00:17:33,950
temperature in the atmosphere due to the

372
00:17:39,220 --> 00:17:36,350
relative transfer and we are also

373
00:17:43,420 --> 00:17:39,230
working with people in Japan in order to

374
00:17:47,220 --> 00:17:43,430
develop a GCM model copelet with the

375
00:17:51,340 --> 00:17:47,230
chemistry in order to model very complex

376
00:17:54,190 --> 00:17:51,350
planets like like the title ii look at

377
00:17:56,410 --> 00:17:54,200
planets next to the star about which we

378
00:17:59,100 --> 00:17:56,420
we know that the chemistry is different

379
00:18:02,710 --> 00:17:59,110
between the two sides of the planet the

380
00:18:04,870 --> 00:18:02,720
the influx at one and the dark one but

381
00:18:08,530 --> 00:18:04,880
we have to consider that there will be

382
00:18:10,960 --> 00:18:08,540
very strong winds here in the in the in

383
00:18:12,730 --> 00:18:10,970
the middle of these two in this two

384
00:18:14,830 --> 00:18:12,740
parties and we can solve this problem

385
00:18:17,290 --> 00:18:14,840
this observational problem just only

386
00:18:19,480 --> 00:18:17,300
Copeland together the gcn so the

387
00:18:24,370 --> 00:18:19,490
aerodynamics of the atmosphere and the

388
00:18:27,370 --> 00:18:24,380

chemistry so yes these are these are the

389
00:18:30,100 --> 00:18:27,380
general results of my of my present

390
00:18:32,200 --> 00:18:30,110
research so as I said we are able now to

391
00:18:34,570 --> 00:18:32,210
uncouple the effort of life and the

392
00:18:36,760 --> 00:18:34,580
effort of photochemistry and we are able

393
00:18:38,800 --> 00:18:36,770
to compare the earth disequilibrium and

394
00:18:42,160 --> 00:18:38,810
the mast is equilibrium we are moving

395
00:18:45,220 --> 00:18:42,170
forward to add 7 to reproduce the

396
00:18:53,539 --> 00:18:45,230
results for other planets and moons so

397
00:18:53,549 --> 00:19:06,499
yeah Thank You Eugene you any questions

398
00:19:12,659 --> 00:19:10,109
when you can when you compute early

399
00:19:15,210 --> 00:19:12,669
early model earth and compared to Mars

400
00:19:17,580 --> 00:19:15,220
do you consider a planetary degassing

401
00:19:20,279 --> 00:19:17,590
two of the primary gases like after

402
00:19:24,899 --> 00:19:20,289
accretion no no I'm considering just the

403
00:19:26,659 --> 00:19:24,909
present present the models and I'm not

404
00:19:32,070 --> 00:19:26,669
considering the fluxes from the surface

405
00:19:33,869 --> 00:19:32,080
G yeah sure sure I mean actually if you

406
00:19:36,839 --> 00:19:33,879
consider all the processes the physical

407
00:19:39,359 --> 00:19:36,849
processes your model should be in steady

408
00:19:43,320 --> 00:19:39,369
state plus four minutes this is why we