AB GRAD CON23

1
00:00:04,230 --> 00:00:11,410
[Music]

2
00:00:16,189 --> 00:00:13,850
alrighty hi everyone thanks for having

3
00:00:17,810 --> 00:00:16,199
me today my name is Michaela Liang I'm

4
00:00:19,910 --> 00:00:17,820
currently a PhD candidate at the

5
00:00:22,130 --> 00:00:19,920
University of California Riverside

6
00:00:24,230 --> 00:00:22,140
um I'll be talking to you today about my

7
00:00:26,029 --> 00:00:24,240
work on novel methylated biosignatures

8
00:00:27,890 --> 00:00:26,039
and specifically their application to

9
00:00:28,910 --> 00:00:27,900
exoplanets which I usually don't have to

10
00:00:31,730 --> 00:00:28,920
say because I'm usually talking to

11
00:00:33,770 --> 00:00:31,740
astronomers so that's kind of fun

12
00:00:36,049 --> 00:00:33,780
um there's a little bit of a breakdown

13
00:00:37,970 --> 00:00:36,059

diagram here on the far side that's my

14
00:00:39,950 --> 00:00:37,980
left so your right

15
00:00:41,389 --> 00:00:39,960
um that's kind of showing the processing

16
00:00:43,850 --> 00:00:41,399
of these molecules all the way from

17
00:00:45,530 --> 00:00:43,860
surface fluxes atmospheric chemistry

18
00:00:46,790 --> 00:00:45,540
um the production of spectral features

19
00:00:49,310 --> 00:00:46,800
and we're kind of thinking about how

20
00:00:51,470 --> 00:00:49,320
this will vary across a variety of

21
00:00:54,110 --> 00:00:51,480
Stellar types so that's kind of just a

22
00:00:56,029 --> 00:00:54,120
very quick summary breakdown

23
00:00:57,950 --> 00:00:56,039
um so let's jump into talking about why

24
00:01:00,590 --> 00:00:57,960
we're specifically interested in these

25
00:01:03,110 --> 00:01:00,600
methylated gases um and the the answer

26
00:01:04,670 --> 00:01:03,120
is largely that there's a major false

27
00:01:06,649 --> 00:01:04,680
positive problem

28
00:01:08,210 --> 00:01:06,659
um for the first biosignature detections

29
00:01:10,250 --> 00:01:08,220
a lot of molecules

30
00:01:11,990 --> 00:01:10,260
um Like Oxygen ozone methane things like

31
00:01:14,690 --> 00:01:12,000
that that we expect to be potentially

32
00:01:16,670 --> 00:01:14,700
the first molecules detected

33
00:01:18,590 --> 00:01:16,680
um that could be connected to life in

34
00:01:20,810 --> 00:01:18,600
terrestrial exoplanet atmospheres can

35
00:01:22,370 --> 00:01:20,820
also be produced by a variety of

36
00:01:24,950 --> 00:01:22,380
planetary processes including

37
00:01:26,870 --> 00:01:24,960
thermodynamic equilibrium chemistry

38
00:01:29,390 --> 00:01:26,880

um and so these methylated gases are

39
00:01:32,090 --> 00:01:29,400
specifically uh almost exclusively

40
00:01:33,649 --> 00:01:32,100
produced by life and all of the other

41
00:01:35,270 --> 00:01:33,659
Pathways that we've investigated have

42
00:01:37,429 --> 00:01:35,280
been very minimal so we're really

43
00:01:39,590 --> 00:01:37,439
excited that these gases could

44
00:01:42,890 --> 00:01:39,600
potentially be a very strong affirmative

45
00:01:45,050 --> 00:01:42,900
uh signal of life and these gases are

46
00:01:48,109 --> 00:01:45,060
generated by the process of volatile

47
00:01:50,990 --> 00:01:48,119
methylation which actually we believe to

48
00:01:53,810 --> 00:01:51,000
be a descendant or perhaps a Rel

49
00:01:55,609 --> 00:01:53,820
relative in some way of the process of

50
00:01:57,530 --> 00:01:55,619
DNA methylation which for you biologists

51
00:01:59,210 --> 00:01:57,540
out there I'm sure you're all much more

52
00:02:01,310 --> 00:01:59,220
familiar with than I but we see volatile

53
00:02:04,429 --> 00:02:01,320
methylation in a variety of different

54
00:02:06,649 --> 00:02:04,439
ecosystems including microbial mats the

55
00:02:08,510 --> 00:02:06,659
open ocean and primarily actually a lot

56
00:02:10,729 --> 00:02:08,520
of terrestrial Marine uh kind of

57
00:02:12,830 --> 00:02:10,739
crossover ecosystems

58
00:02:15,050 --> 00:02:12,840
um we also see it done by a variety of

59
00:02:16,670 --> 00:02:15,060
organisms primarily a single cellular

60
00:02:18,949 --> 00:02:16,680
life but we do also see everyone's

61
00:02:22,430 --> 00:02:18,959
favorite Brassica vegetables

62
00:02:23,930 --> 00:02:22,440
um also produce methylated gases

63
00:02:26,150 --> 00:02:23,940

um and we think in particular that

64
00:02:28,550 --> 00:02:26,160
methylation is connected to the process

65
00:02:30,350 --> 00:02:28,560
of environmental detoxification

66
00:02:32,330 --> 00:02:30,360
um and that the Need For Life to kind of

67
00:02:33,830 --> 00:02:32,340
control its environment is possibly a

68
00:02:35,570 --> 00:02:33,840
fundamental characteristic of life

69
00:02:37,130 --> 00:02:35,580
itself and so when we're thinking about

70
00:02:40,130 --> 00:02:37,140
you know what life might look like under

71
00:02:41,570 --> 00:02:40,140
fundamentally different biogeochemistry

72
00:02:43,009 --> 00:02:41,580
um you know we're it's probably still

73
00:02:44,330 --> 00:02:43,019
going to need to be controlling that

74
00:02:46,190 --> 00:02:44,340
surroundings in some ways we're really

75
00:02:47,150 --> 00:02:46,200
excited about that potential tie-in as

76
00:02:48,710 --> 00:02:47,160
well

77
00:02:50,809 --> 00:02:48,720
um we're not the first people to think

78
00:02:52,910 --> 00:02:50,819
about methylated biosignatures there are

79
00:02:56,270 --> 00:02:52,920
uh previous study specifically cigarette

80
00:02:58,910 --> 00:02:56,280
all 2005 and domigal Goldman at all 2011

81
00:03:01,970 --> 00:02:58,920
which specifically show one an enhanced

82
00:03:03,650 --> 00:03:01,980
buildup level around M dwarfs and two a

83
00:03:06,229 --> 00:03:03,660
secondary ethane biosignature that's

84
00:03:08,210 --> 00:03:06,239
produced by atmospheric photolysis of

85
00:03:09,710 --> 00:03:08,220
dimethyl sulfide and dimethyl disulfide

86
00:03:11,809 --> 00:03:09,720
and that produces a potentially

87
00:03:13,130 --> 00:03:11,819
detectable ethane signature

88
00:03:15,649 --> 00:03:13,140

um and so we're going to follow a

89
00:03:17,630 --> 00:03:15,659
relatively similar uh pathway we're

90
00:03:19,309 --> 00:03:17,640
jumping from labland that we've been in

91
00:03:20,869 --> 00:03:19,319
for the last couple of talks to modeling

92
00:03:23,330 --> 00:03:20,879
land

93
00:03:25,490 --> 00:03:23,340
um and uh primarily we're going to be

94
00:03:26,930 --> 00:03:25,500
talking about photochemical and spectral

95
00:03:28,309 --> 00:03:26,940
modeling basically thinking about how

96
00:03:30,290 --> 00:03:28,319
these gases are processed in the

97
00:03:32,630 --> 00:03:30,300
atmosphere and what those potential

98
00:03:34,790 --> 00:03:32,640
signals might look like

99
00:03:37,250 --> 00:03:34,800
um just jumping into some results

100
00:03:40,190 --> 00:03:37,260
um we have first here methyl bromide

101
00:03:42,229 --> 00:03:40,200
which is again on your left and we have

102
00:03:43,550 --> 00:03:42,239
methyl iodine which is on I think you're

103
00:03:45,830 --> 00:03:43,560
right

104
00:03:47,690 --> 00:03:45,840
um and you'll notice that as I said

105
00:03:49,250 --> 00:03:47,700
before for methyl chloride they see an

106
00:03:51,890 --> 00:03:49,260
atmospheric buildup level that's much

107
00:03:54,710 --> 00:03:51,900
higher around these M dwarf uh cooler

108
00:03:56,869 --> 00:03:54,720
better stars and we actually see that uh

109
00:03:58,789 --> 00:03:56,879
buildup replicated and actually even

110
00:04:00,589 --> 00:03:58,799
more enhanced for methyl bromide and

111
00:04:03,589 --> 00:04:00,599
this result from methyl is from like

112
00:04:05,270 --> 00:04:03,599
literally last week so that's brand new

113
00:04:06,770 --> 00:04:05,280

um and we're also seeing again the same

114
00:04:08,869 --> 00:04:06,780
sort of enhanced buildup you'll notice

115
00:04:10,009 --> 00:04:08,879
that it's to a lesser degree and we

116
00:04:12,110 --> 00:04:10,019
think that's probably because it's just

117
00:04:15,589 --> 00:04:12,120
a larger molecule and so it's a larger

118
00:04:17,750 --> 00:04:15,599
molecule it's going to be hit by more uh

119
00:04:18,890 --> 00:04:17,760
potentially active uh photochemical

120
00:04:21,650 --> 00:04:18,900
light

121
00:04:24,230 --> 00:04:21,660
so we use this photochemical model to to

122
00:04:25,490 --> 00:04:24,240
create profiles of gases in the

123
00:04:27,530 --> 00:04:25,500
atmosphere and kind of figure out where

124
00:04:28,850 --> 00:04:27,540
everything is where where it's at in the

125
00:04:30,890 --> 00:04:28,860
atmosphere and then we're using like I

126
00:04:32,930 --> 00:04:30,900
said a series of spectral models

127
00:04:34,249 --> 00:04:32,940
um so this these are mid-infrared

128
00:04:35,810 --> 00:04:34,259
emission Spectra

129
00:04:37,310 --> 00:04:35,820
um and the most important thing that

130
00:04:39,350 --> 00:04:37,320
I'll call your attention to here there's

131
00:04:40,790 --> 00:04:39,360
kind of a lot going on but the bottom

132
00:04:42,590 --> 00:04:40,800
row is actually showing an experiment

133
00:04:44,990 --> 00:04:42,600
that we did where we add multiple

134
00:04:46,550 --> 00:04:45,000
methylated gases in this case methyl

135
00:04:48,290 --> 00:04:46,560
chloride and methyl bromide and you'll

136
00:04:50,390 --> 00:04:48,300
actually notice that the features that

137
00:04:51,469 --> 00:04:50,400
we see especially for Proxima Centauri

138
00:04:53,210 --> 00:04:51,479

which is going to be that plot all the

139
00:04:54,770 --> 00:04:53,220
way down in the bottom corner

140
00:04:56,510 --> 00:04:54,780
um that feature is actually a little bit

141
00:04:57,890 --> 00:04:56,520
wider and a little bit deeper than just

142
00:04:59,510 --> 00:04:57,900
kind of the simple sum of the features

143
00:05:01,490 --> 00:04:59,520
and that's partially because we're doing

144
00:05:02,810 --> 00:05:01,500
self-consistent photochemistry

145
00:05:05,450 --> 00:05:02,820
um and so you do get higher buildup

146
00:05:07,430 --> 00:05:05,460
levels and also because this absorption

147
00:05:09,469 --> 00:05:07,440
feature near 10 microns is actually the

148
00:05:11,570 --> 00:05:09,479
acetah halogen Bond and so acetochlorine

149
00:05:12,890 --> 00:05:11,580
and Cedar bromine are sort of uh next to

150
00:05:14,390 --> 00:05:12,900
each other and overlapping a little bit

151
00:05:16,670 --> 00:05:14,400
but really creating this much larger

152
00:05:18,830 --> 00:05:16,680
feature um so we're optimistic that a

153
00:05:20,689 --> 00:05:18,840
future telescope capable of minimum

154
00:05:22,029 --> 00:05:20,699
infrared emission spectroscopy could

155
00:05:24,529 --> 00:05:22,039
detect these

156
00:05:26,330 --> 00:05:24,539
and we also think that while this could

157
00:05:27,950 --> 00:05:26,340
detect a methylated gas we could

158
00:05:31,010 --> 00:05:27,960
potentially fingerprint a specific

159
00:05:34,189 --> 00:05:31,020
methylated gas using extremely high

160
00:05:36,469 --> 00:05:34,199
resolution ground-based spectroscopy

161
00:05:38,930 --> 00:05:36,479
um and potentially one mode that we

162
00:05:40,430 --> 00:05:38,940
could use for the emission spectroscopy

163
00:05:42,110 --> 00:05:40,440

that I was just showing is the life

164
00:05:44,090 --> 00:05:42,120
telescope which is a concept Mission

165
00:05:45,350 --> 00:05:44,100
that's actually run by the European

166
00:05:47,270 --> 00:05:45,360
Space Agency where they're using

167
00:05:50,150 --> 00:05:47,280
interferometry to essentially get a

168
00:05:51,469 --> 00:05:50,160
larger uh approximation of a telescope

169
00:05:52,550 --> 00:05:51,479
rather than putting like 100 meter

170
00:05:53,930 --> 00:05:52,560
telescope in space because that's

171
00:05:54,770 --> 00:05:53,940
actually going to be very difficult to

172
00:05:56,090 --> 00:05:54,780
do

173
00:05:58,490 --> 00:05:56,100
um and so you could see here that

174
00:05:59,749 --> 00:05:58,500
there's simulated error bars for the

175
00:06:01,189 --> 00:05:59,759
observations

176
00:06:03,230 --> 00:06:01,199
um and that there's kind of a noticeable

177
00:06:05,090 --> 00:06:03,240
difference between the atmospheres

178
00:06:07,490 --> 00:06:05,100
without these methylated gases and

179
00:06:09,830 --> 00:06:07,500
especially the higher flux cases and we

180
00:06:13,070 --> 00:06:09,840
can also look at this as a kind of

181
00:06:14,150 --> 00:06:13,080
comparison to the sigma of the detection

182
00:06:15,650 --> 00:06:14,160
and you can see we get some pretty

183
00:06:18,050 --> 00:06:15,660
significantly large features here and

184
00:06:20,090 --> 00:06:18,060
we're optimistic again that if any bio

185
00:06:22,249 --> 00:06:20,100
signatures are detected on these planets

186
00:06:24,050 --> 00:06:22,259
these are very optimistic planets were

187
00:06:26,809 --> 00:06:24,060
simulating for but hopefully these

188
00:06:28,189 --> 00:06:26,819

methylated gases will be among uh those

189
00:06:29,870 --> 00:06:28,199
bio signatures that it's possible to

190
00:06:32,570 --> 00:06:29,880
detect so I will leave you with my

191
00:06:34,730 --> 00:06:32,580
conclusions I think I am right on time

192
00:06:36,590 --> 00:06:34,740
um I'm at poster nine which is right on

193
00:06:38,270 --> 00:06:36,600
the other side of this wall or you can

194
00:06:39,300 --> 00:06:38,280
feel free to contact me my information

195
00:06:44,029 --> 00:06:39,310
is on the slide