1
00:00:06,230 --> 00:00:04,150
on most days we get a chance to see the

2
00:00:09,030 --> 00:00:06,240
international space station crew members

3
00:00:11,350 --> 00:00:09,040
working on science experiments

4
00:00:14,150 --> 00:00:11,360
sometimes we get to see the experiments

5
00:00:16,470 --> 00:00:14,160
themselves as they do their thing

6
00:00:18,950 --> 00:00:16,480
recently the international space station

7
00:00:21,750 --> 00:00:18,960
program science office posted a video

8
00:00:23,349 --> 00:00:21,760
clip on the real nasa youtube channel

9
00:00:24,950 --> 00:00:23,359
from a combustion experiment that's

10
00:00:26,550 --> 00:00:24,960
underway and that clip has caught an

11
00:00:33,510 --> 00:00:26,560
awful lot of attention

12
00:00:39,030 --> 00:00:35,830
that's from the flame extinguishment

13
00:00:41,190 --> 00:00:39,040

experiment 2 or flex 2.

14
00:00:43,750 --> 00:00:41,200
earlier this week i spoke with dr tom

15
00:00:46,549 --> 00:00:43,760
avedisian of cornell university who is

16
00:00:48,549 --> 00:00:46,559
the flex 2 co-investigator who requested

17
00:00:51,029 --> 00:00:48,559
that particular test burn

18
00:00:53,430 --> 00:00:51,039
to find out what it is we're seeing here

19
00:00:55,750 --> 00:00:53,440
and what scientists are trying to learn

20
00:00:58,310 --> 00:00:55,760
from burning things in space

21
00:01:00,310 --> 00:00:58,320
well our overarching objectives are to

22
00:01:03,270 --> 00:01:00,320
obtain information about how liquid

23
00:01:05,030 --> 00:01:03,280
fuels burn so we can design ultimately

24
00:01:08,550 --> 00:01:05,040
more efficient combustion engines used

25
00:01:10,630 --> 00:01:08,560
in transportation systems on earth

26
00:01:12,870 --> 00:01:10,640
the the problem with that is that real

27
00:01:15,270 --> 00:01:12,880
liquid fuels like gasoline diesel and

28
00:01:17,109 --> 00:01:15,280
jet fuel are so complex

29
00:01:20,070 --> 00:01:17,119
that it's really a hopeless task to

30
00:01:21,670 --> 00:01:20,080
develop models for how they burn as they

31
00:01:24,070 --> 00:01:21,680
contain hundreds of miscible

32
00:01:27,429 --> 00:01:24,080
constituents with a wide range of

33
00:01:29,190 --> 00:01:27,439
boiling points propensities to form soot

34
00:01:31,270 --> 00:01:29,200
during combustion

35
00:01:33,749 --> 00:01:31,280
and heats of vaporization soot is the

36
00:01:34,469 --> 00:01:33,759
black carbonaceous material we sometimes

37
00:01:36,550 --> 00:01:34,479
see

38
00:01:38,390 --> 00:01:36,560

spew out the dispute out of the exhaust

39
00:01:40,390 --> 00:01:38,400
line of diesel trucks which is

40
00:01:41,510 --> 00:01:40,400
responsible for a whole host of health

41
00:01:43,830 --> 00:01:41,520
risks

42
00:01:45,510 --> 00:01:43,840
where we are addressing this problem our

43
00:01:48,950 --> 00:01:45,520
approach by studying the combustion

44
00:01:51,830 --> 00:01:48,960
dynamics of fuel blends comprised of a

45
00:01:54,789 --> 00:01:51,840
much smaller number of constituents say

46
00:01:56,469 --> 00:01:54,799
for example two or three ideally

47
00:01:58,709 --> 00:01:56,479
with the hope that they will replicate

48
00:01:59,749 --> 00:01:58,719
certain combustion targets of the real

49
00:02:01,749 --> 00:01:59,759
fuel

50
00:02:04,230 --> 00:02:01,759
we would then develop the understanding

51
00:02:06,389 --> 00:02:04,240
of that simpler blend which we call a

52
00:02:08,550 --> 00:02:06,399
surrogate and use the combustion

53
00:02:10,869 --> 00:02:08,560
properties of the surrogate to assess

54
00:02:13,910 --> 00:02:10,879
the performance of the real fuel

55
00:02:16,710 --> 00:02:13,920
now in fact you're doing the these uh

56
00:02:18,949 --> 00:02:16,720
experiments in space by burning just

57
00:02:20,949 --> 00:02:18,959
single droplets of fuel right tell me

58
00:02:23,750 --> 00:02:20,959
why that why you do it that way

59
00:02:25,270 --> 00:02:23,760
well that that's that's correct our our

60
00:02:27,430 --> 00:02:25,280
strategy has been developed the

61
00:02:30,390 --> 00:02:27,440
combustion properties for evaluating a

62
00:02:32,869 --> 00:02:30,400
surrogate by using the simplest possible

63
00:02:36,390 --> 00:02:32,879

configuration of burning for a liquid

64
00:02:38,790 --> 00:02:36,400
fuel namely a droplet burning under

65
00:02:41,670 --> 00:02:38,800
conditions that promote spherically

66
00:02:43,750 --> 00:02:41,680
symmetric gas transport this kind of

67
00:02:45,990 --> 00:02:43,760
combustion symmetry is currently the

68
00:02:48,309 --> 00:02:46,000
only one for a liquid fuel that can be

69
00:02:51,350 --> 00:02:48,319
modeled using detailed

70
00:02:53,350 --> 00:02:51,360
simulation or first principles approach

71
00:02:55,350 --> 00:02:53,360
where no sub models or adjustable

72
00:02:57,589 --> 00:02:55,360
constants are required

73
00:03:00,309 --> 00:02:57,599
this is precisely what is needed to

74
00:03:03,110 --> 00:03:00,319
evaluate the efficacy of a surrogate to

75
00:03:05,670 --> 00:03:03,120
perform like a real fuel it is intended

76
00:03:08,149 --> 00:03:05,680
to replicate and in space you get to do

77
00:03:10,390 --> 00:03:08,159
these experiments inside an apparatus

78
00:03:12,949 --> 00:03:10,400
called the multi-use droplet combustion

79
00:03:16,550 --> 00:03:12,959
apparatus that allows you to control

80
00:03:17,670 --> 00:03:16,560
variables right that is correct the mdca

81
00:03:20,390 --> 00:03:17,680
as its

82
00:03:23,750 --> 00:03:20,400
shorthand notation has the capability to

83
00:03:25,830 --> 00:03:23,760
control the droplet size which is a very

84
00:03:28,229 --> 00:03:25,840
important parameter that influences soot

85
00:03:30,630 --> 00:03:28,239
formation and radiative losses

86
00:03:32,390 --> 00:03:30,640
as well as the ambient oxygen and inner

87
00:03:34,070 --> 00:03:32,400
gas concentration

88
00:03:35,270 --> 00:03:34,080

and pressure up to about three

89
00:03:38,710 --> 00:03:35,280
atmospheres

90
00:03:40,550 --> 00:03:38,720
currently we do experiments my component

91
00:03:43,030 --> 00:03:40,560
of the flex project is essentially at

92
00:03:45,110 --> 00:03:43,040
room temperature air

93
00:03:47,190 --> 00:03:45,120
obviously the facility includes storage

94
00:03:49,030 --> 00:03:47,200
chambers for a range of fuels with the

95
00:03:51,350 --> 00:03:49,040
ones we are investigating being

96
00:03:53,190 --> 00:03:51,360
representative of components of real

97
00:03:55,750 --> 00:03:53,200
transportation fuels

98
00:03:58,309 --> 00:03:55,760
now we mentioned earlier that there's a

99
00:04:00,550 --> 00:03:58,319
a video on youtube that shows kind of a

100
00:04:03,270 --> 00:04:00,560
remarkable burn and i'd like to play

101
00:04:05,990 --> 00:04:03,280
that again and have you described for me

102
00:04:07,190 --> 00:04:06,000
what it is that we see in this video

103
00:04:09,830 --> 00:04:07,200
okay

104
00:04:11,830 --> 00:04:09,840
um it's a very delicate operation

105
00:04:14,470 --> 00:04:11,840
there's a zooming out and you'll see

106
00:04:15,910 --> 00:04:14,480
very quickly the the activation and the

107
00:04:17,909 --> 00:04:15,920
ignition event

108
00:04:20,150 --> 00:04:17,919
the droplet looks motionless but

109
00:04:22,150 --> 00:04:20,160
actually it is moving a little bit

110
00:04:24,790 --> 00:04:22,160
and you'll see in the lower left-hand

111
00:04:26,070 --> 00:04:24,800
corner the flame disappearing and then

112
00:04:28,629 --> 00:04:26,080
reappearing

113
00:04:31,270 --> 00:04:28,639

and we believe that this is the result

114
00:04:34,390 --> 00:04:31,280
of movement of the droplet such that

115
00:04:37,670 --> 00:04:34,400
when the droplet is moving fresh oxygen

116
00:04:39,990 --> 00:04:37,680
is drawn into the combustion zone but it

117
00:04:41,909 --> 00:04:40,000
also depletes the oxygen on the back

118
00:04:44,070 --> 00:04:41,919
side of the droplet which causes

119
00:04:47,030 --> 00:04:44,080
extinction but that movement of the

120
00:04:50,150 --> 00:04:47,040
droplet allows the flame to close on the

121
00:04:52,469 --> 00:04:50,160
backside the continued movement it opens

122
00:04:55,110 --> 00:04:52,479
up again and you can execute multiple

123
00:04:57,350 --> 00:04:55,120
cycles of this what appears like a

124
00:04:59,189 --> 00:04:57,360
jellyfish type of motion

125
00:05:01,830 --> 00:04:59,199
i mean we don't really know

126
00:05:03,909 --> 00:05:01,840
the the detailed mechanism for this this

127
00:05:05,830 --> 00:05:03,919
is purely speculation on our part but

128
00:05:07,670 --> 00:05:05,840
this is what we think is happening

129
00:05:09,189 --> 00:05:07,680
but as you explained earlier one of the

130
00:05:11,350 --> 00:05:09,199
things that you're looking at is what

131
00:05:13,670 --> 00:05:11,360
happens to the soot during these burns

132
00:05:16,070 --> 00:05:13,680
and you really can't see that in that

133
00:05:17,830 --> 00:05:16,080
video but you provided us with another

134
00:05:19,670 --> 00:05:17,840
uh video clip

135
00:05:22,790 --> 00:05:19,680
from a black and white camera in the

136
00:05:25,350 --> 00:05:22,800
mdca i want to show that because it also

137
00:05:27,110 --> 00:05:25,360
has some pretty remarkable movement in

138
00:05:28,070 --> 00:05:27,120

there and get you to describe what we're

139
00:05:31,029 --> 00:05:28,080
seeing

140
00:05:34,550 --> 00:05:31,039
well this video is of a toluene fuel

141
00:05:36,310 --> 00:05:34,560
toluene is a constituent of uh gasoline

142
00:05:39,990 --> 00:05:36,320
here you see as soon as the ignition

143
00:05:42,710 --> 00:05:40,000
process occurs soot explodes into view

144
00:05:44,790 --> 00:05:42,720
and as you noted this is a backlit image

145
00:05:47,270 --> 00:05:44,800
so we see the dropper that's the black

146
00:05:50,150 --> 00:05:47,280
ball that's kind of very slowly drifting

147
00:05:51,749 --> 00:05:50,160
and the soot particles are almost in the

148
00:05:54,950 --> 00:05:51,759
state of left um

149
00:05:56,870 --> 00:05:54,960
animated levitation around the droplet

150
00:05:58,550 --> 00:05:56,880
the flame is actually extinguished but

151
00:06:01,029 --> 00:05:58,560
you can't see it here

152
00:06:03,590 --> 00:06:01,039
um the droplet is drifting but the soot

153
00:06:06,469 --> 00:06:03,600
particles remain somewhat in place that

154
00:06:08,710 --> 00:06:06,479
is a remarkable illustration of the

155
00:06:11,670 --> 00:06:08,720
formation of soot under the spherically

156
00:06:13,670 --> 00:06:11,680
symmetric condition it's remarkable even

157
00:06:15,510 --> 00:06:13,680
for for the layman to look at that and

158
00:06:17,670 --> 00:06:15,520
and to have just a beginning of an

159
00:06:19,510 --> 00:06:17,680
understanding of what we're seeing there

160
00:06:21,590 --> 00:06:19,520
can you explain to us

161
00:06:24,390 --> 00:06:21,600
how you imagine the results what you're

162
00:06:25,590 --> 00:06:24,400
getting in these burns how they can be

163
00:06:27,909 --> 00:06:25,600

applicable

164
00:06:30,390 --> 00:06:27,919
for in future uses

165
00:06:32,309 --> 00:06:30,400
well as i as i remarked earlier we have

166
00:06:35,189 --> 00:06:32,319
been using the multi-user droplet

167
00:06:37,909 --> 00:06:35,199
combustion apparatus on on the space

168
00:06:40,390 --> 00:06:37,919
station to study how surrogates for real

169
00:06:43,270 --> 00:06:40,400
liquid transportation fuels burn when

170
00:06:44,469 --> 00:06:43,280
subjected to the idealized environment

171
00:06:46,790 --> 00:06:44,479
of

172
00:06:48,390 --> 00:06:46,800
no convection and no relative droplet

173
00:06:50,230 --> 00:06:48,400
gas velocity that's going to create

174
00:06:53,110 --> 00:06:50,240
spherical drop of flames

175
00:06:54,870 --> 00:06:53,120
we feel there are few configurations

176
00:06:57,270 --> 00:06:54,880
better suited to get this type of

177
00:06:58,870 --> 00:06:57,280
understanding i would also note

178
00:07:01,029 --> 00:06:58,880
or like to note that with the new

179
00:07:03,350 --> 00:07:01,039
generation of fuels emerging that will

180
00:07:05,830 --> 00:07:03,360
be derived from a wide range of biofeed

181
00:07:08,390 --> 00:07:05,840
stocks like algae camelina soybean and

182
00:07:10,150 --> 00:07:08,400
so forth the mdca

183
00:07:12,150 --> 00:07:10,160
with the spherically symmetric burning

184
00:07:14,629 --> 00:07:12,160
process it can promote is i think well

185
00:07:16,550 --> 00:07:14,639
positioned to reveal the influence of

186
00:07:19,110 --> 00:07:16,560
fuel composition and droplet size

187
00:07:21,350 --> 00:07:19,120
effects on ignition combustion kinetic

188
00:07:23,110 --> 00:07:21,360

measurement

189
00:07:25,830 --> 00:07:23,120
combustion kinetic mechanisms and so

190
00:07:28,150 --> 00:07:25,840
forth that control burning developing

191
00:07:30,870 --> 00:07:28,160
surrogates for these biofuels

192
00:07:32,790 --> 00:07:30,880
is essential to access this information

193
00:07:35,189 --> 00:07:32,800
and and armed with it

194
00:07:37,909 --> 00:07:35,199
uh the combustion chemistry for these

195
00:07:41,110 --> 00:07:37,919
simpler brands uh other characteristics

196
00:07:43,430 --> 00:07:41,120
of biofuels uh can be obtained uh that

197
00:07:45,670 --> 00:07:43,440
should ultimately uh allow us to predict

198
00:07:47,749 --> 00:07:45,680
their performance in combustion engines

199
00:07:49,909 --> 00:07:47,759
for this new generation of fuels

200
00:07:51,749 --> 00:07:49,919
be very interesting to keep track of

201
00:07:53,749 --> 00:07:51,759
this as it goes forward and see how it

202
00:07:56,950 --> 00:07:53,759
works i appreciate you taking the time

203
00:07:59,670 --> 00:07:56,960
to explain it to us thank you very much

204
00:08:02,230 --> 00:07:59,680
dr tom avedisian of cornell university

205
00:08:03,749 --> 00:08:02,240
is a co-investigator of the flex 2