



**BLACK HOLE JETS
ON A NASA SUPERCOMPUTER**

1
00:00:05,210 --> 00:00:02,649
foreign

2
00:00:06,950 --> 00:00:05,220
there are some problems in astrophysics

3
00:00:08,099 --> 00:00:06,960
that can't be solved on a normal

4
00:00:10,190 --> 00:00:08,109
computer

5
00:00:23,890 --> 00:00:10,200
[Music]

6
00:00:31,790 --> 00:00:27,410
my name is Ryan Tanner I study active

7
00:00:34,910 --> 00:00:31,800
collect nuclei and star formation and

8
00:00:37,310 --> 00:00:34,920
how they affect galaxies I have been

9
00:00:40,369 --> 00:00:37,320
doing research and computer simulations

10
00:00:41,389 --> 00:00:40,379
of Galactic outflows for a number of

11
00:00:44,569 --> 00:00:41,399
years now

12
00:00:47,389 --> 00:00:44,579
my name is Kim Weaver and I work at Nasa

13
00:00:51,049 --> 00:00:47,399

I've been looking at AGN for a very long

14

00:00:53,930 --> 00:00:51,059

time and we just don't understand how

15

00:00:57,670 --> 00:00:53,940

the Jets impact the galaxies in these

16

00:01:02,510 --> 00:00:59,150

[Music]

17

00:01:04,969 --> 00:01:02,520

an AGN is where you have a supermassive

18

00:01:08,810 --> 00:01:04,979

black hole at the center of a galaxy and

19

00:01:10,310 --> 00:01:08,820

occasionally there's gas or a star or

20

00:01:13,070 --> 00:01:10,320

something that gets too close to the

21

00:01:15,530 --> 00:01:13,080

supermassive black hole and it begins to

22

00:01:17,929 --> 00:01:15,540

get pulled in by gravity but when it

23

00:01:21,590 --> 00:01:17,939

does that it releases a huge amount of

24

00:01:24,710 --> 00:01:21,600

energy there are strong Jets and weak

25

00:01:26,570 --> 00:01:24,720

Jets high intensity AGN large Jets have

26

00:01:28,429 --> 00:01:26,580

been studied for a long time we've seen

27

00:01:30,770 --> 00:01:28,439

they're very obvious you can see them on

28

00:01:32,450 --> 00:01:30,780

the sky you see them bright in the radio

29

00:01:36,350 --> 00:01:32,460

emission you see them bright in the

30

00:01:39,469 --> 00:01:36,360

optical the largest ones can get several

31

00:01:42,109 --> 00:01:39,479

million light years in size the low

32

00:01:44,569 --> 00:01:42,119

Luminosity jets are much harder to find

33

00:01:46,789 --> 00:01:44,579

and often do not even leave their

34

00:01:48,649 --> 00:01:46,799

galaxies and are very compact we know

35

00:01:50,270 --> 00:01:48,659

some things about the AGN but we don't

36

00:01:52,249 --> 00:01:50,280

know everything it's like a big puzzle

37

00:01:53,810 --> 00:01:52,259

piece we're doing a jigsaw puzzle and

38

00:01:55,550 --> 00:01:53,820

there's pieces that are missing and

39

00:01:58,310 --> 00:01:55,560

there's some that we have fairly well

40

00:02:00,109 --> 00:01:58,320

put together but others where we have no

41

00:02:03,350 --> 00:02:00,119

idea what's there one of the major

42

00:02:06,889 --> 00:02:03,360

puzzle pieces that we're missing is how

43

00:02:09,050 --> 00:02:06,899

these low Luminosity agns impact and

44

00:02:10,550 --> 00:02:09,060

determine the evolution of their host

45

00:02:12,410 --> 00:02:10,560

galaxies

46

00:02:16,820 --> 00:02:12,420

for this problem we have to use super

47

00:02:22,190 --> 00:02:18,670

[Music]

48

00:02:24,890 --> 00:02:22,200

for my research I use a code called

49

00:02:28,729 --> 00:02:24,900

Athena it can do anything from planet

50

00:02:31,190 --> 00:02:28,739

formation star formation supernovas and

51
00:02:34,430 --> 00:02:31,200
anything in between and I did some

52
00:02:36,830 --> 00:02:34,440
modifications to it in order to tailor

53
00:02:38,630 --> 00:02:36,840
it to my exact problem that I have the

54
00:02:40,430 --> 00:02:38,640
process of watching this was impressive

55
00:02:43,550 --> 00:02:40,440
because you know there's so much

56
00:02:46,130 --> 00:02:43,560
computation going in and there's so much

57
00:02:48,229 --> 00:02:46,140
Focus going into this project and the

58
00:02:55,430 --> 00:02:48,239
outcome is going to be something pretty

59
00:02:55,440 --> 00:02:59,830
foreign

60
00:03:05,449 --> 00:03:02,210
came to me and said I need a super new

61
00:03:08,330 --> 00:03:05,459
Peter and I said okay what what because

62
00:03:10,550 --> 00:03:08,340
I had never helped anybody get the super

63
00:03:13,369 --> 00:03:10,560

computer time I've seen it I've been in

64

00:03:17,210 --> 00:03:13,379

the room it's amazing you submit a

65

00:03:19,670 --> 00:03:17,220

request online in the system you have to

66

00:03:21,949 --> 00:03:19,680

provide a justification for what you're

67

00:03:23,869 --> 00:03:21,959

going to use you have to explain the

68

00:03:26,089 --> 00:03:23,879

project behind it you have to explain

69

00:03:28,309 --> 00:03:26,099

basically what you expect to get out of

70

00:03:30,530 --> 00:03:28,319

it and how you will use those results

71

00:03:32,869 --> 00:03:30,540

and that goes through a review process

72

00:03:34,970 --> 00:03:32,879

that can take several months the formal

73

00:03:37,729 --> 00:03:34,980

review process can take anywhere between

74

00:03:40,490 --> 00:03:37,739

six months up to I've Been Told 18

75

00:03:40,500 --> 00:03:45,229

foreign

76

00:03:49,369 --> 00:03:47,390

basically I can use the supercomputer

77

00:03:52,309 --> 00:03:49,379

from anywhere in the world as long as I

78

00:03:54,589 --> 00:03:52,319

have a secure connection to it and then

79

00:03:56,930 --> 00:03:54,599

once I'm logged on to it it's as if I'm

80

00:03:59,030 --> 00:03:56,940

there using the supercomputer in the

81

00:04:02,930 --> 00:03:59,040

actual building where it's housed I can

82

00:04:05,570 --> 00:04:02,940

upload the code that I need to use to

83

00:04:08,869 --> 00:04:05,580

run in any data files that need to go in

84

00:04:10,850 --> 00:04:08,879

for inputs and then I can simply use a

85

00:04:13,250 --> 00:04:10,860

command to submit a job on the

86

00:04:15,050 --> 00:04:13,260

supercomputer and it puts it in a long

87

00:04:19,729 --> 00:04:15,060

queue of different people who have

88

00:04:19,739 --> 00:04:22,490

foreign

89

00:04:31,189 --> 00:04:28,450

[Music]

90

00:04:33,890 --> 00:04:31,199

how things were going and he said it's

91

00:04:36,530 --> 00:04:33,900

going to be another few days because I

92

00:04:38,330 --> 00:04:36,540

have a simulations running so for the

93

00:04:40,310 --> 00:04:38,340

paper that we wrote for this particular

94

00:04:44,210 --> 00:04:40,320

result it was about

95

00:04:45,770 --> 00:04:44,220

800 000 hours of computational time when

96

00:04:48,230 --> 00:04:45,780

I'm actually doing the research and

97

00:04:49,909 --> 00:04:48,240

doing the simulations like I said I

98

00:04:51,890 --> 00:04:49,919

don't think too much about it but when I

99

00:04:54,170 --> 00:04:51,900

talk to other people and explain what

100

00:04:56,210 --> 00:04:54,180

I'm doing that's when I realized oh this

101
00:04:57,830 --> 00:04:56,220
is these are really big simulations and

102
00:04:59,930 --> 00:04:57,840
these are there's a lot of stuff going

103
00:05:02,150 --> 00:04:59,940
on here that most people will never see

104
00:05:04,610 --> 00:05:02,160
or the amount of computational resources

105
00:05:05,230 --> 00:05:04,620
most people will never use in their life

106
00:05:13,870 --> 00:05:05,240
foreign

107
00:05:18,469 --> 00:05:16,670
ER and getting the simulation data back

108
00:05:20,210 --> 00:05:18,479
was a process that just continuously

109
00:05:22,370 --> 00:05:20,220
would do it over several months I would

110
00:05:24,830 --> 00:05:22,380
have to run a simulation download the

111
00:05:26,689 --> 00:05:24,840
data look at it see if there was doing

112
00:05:28,550 --> 00:05:26,699
what I expected it to do if there was

113
00:05:30,469 --> 00:05:28,560

anything that was wrong I had to go back

114

00:05:32,689 --> 00:05:30,479

and figure out what was wrong with the

115

00:05:34,730 --> 00:05:32,699

code then I would make that change to

116

00:05:36,890 --> 00:05:34,740

the code on the supercomputer run on the

117

00:05:38,990 --> 00:05:36,900

simulation Again download the data look

118

00:05:41,510 --> 00:05:39,000

at it and just repeat the process over

119

00:05:43,790 --> 00:05:41,520

many many months over basically a year

120

00:05:46,010 --> 00:05:43,800

fact is sometimes it can take decades to

121

00:05:47,930 --> 00:05:46,020

things happen but you have to have the

122

00:05:50,330 --> 00:05:47,940

patience and that's hopefully that's

123

00:05:51,830 --> 00:05:50,340

what most astronomers have and they need

124

00:05:54,050 --> 00:05:51,840

is patience

125

00:05:56,990 --> 00:05:54,060

because the universe doesn't always bend

126

00:06:06,600 --> 00:05:57,000

to your will and you have to wait to

127

00:06:15,350 --> 00:06:12,710

[Music]

128

00:06:18,170 --> 00:06:15,360

it was one of those things where I

129

00:06:19,969 --> 00:06:18,180

didn't know exactly what would come out

130

00:06:22,570 --> 00:06:19,979

of the simulations that's why we're

131

00:06:27,170 --> 00:06:24,770

and that's sort of the case as it was

132

00:06:29,990 --> 00:06:27,180

here was We Run The simulations and then

133

00:06:32,990 --> 00:06:30,000

something unexpected came out of these

134

00:06:35,390 --> 00:06:33,000

AGN these low power agns actually have a

135

00:06:38,090 --> 00:06:35,400

very large impact on their host galaxies

136

00:06:40,790 --> 00:06:38,100

the blue color in the center the blue

137

00:06:44,270 --> 00:06:40,800

green colors indicate the the Galaxy

138

00:06:46,490 --> 00:06:44,280

itself when you see the pink colors that

139

00:06:49,490 --> 00:06:46,500

are coming out and the purple that is

140

00:06:52,670 --> 00:06:49,500

the actual jet itself the Jets can be

141

00:06:55,670 --> 00:06:52,680

split they can be split by a dense Cloud

142

00:06:59,150 --> 00:06:55,680

into streams as they come out of the

143

00:07:02,029 --> 00:06:59,160

Galaxy they can be deflected which is

144

00:07:04,129 --> 00:07:02,039

they change direction entirely and in

145

00:07:06,469 --> 00:07:04,139

some cases the jet can be entirely

146

00:07:08,990 --> 00:07:06,479

stopped are we seeing star formation

147

00:07:10,670 --> 00:07:09,000

that's being created by the Jets

148

00:07:12,650 --> 00:07:10,680

impacting the clouds which I think would

149

00:07:14,629 --> 00:07:12,660

be really cool because again that says

150

00:07:17,809 --> 00:07:14,639

the black holes are doing something

151
00:07:20,390 --> 00:07:17,819
amazing to the galaxies by being there

152
00:07:22,850 --> 00:07:20,400
or we can see that the Jets could be

153
00:07:24,830 --> 00:07:22,860
disrupting the star formation and

154
00:07:26,990 --> 00:07:24,840
slowing it down which is another

155
00:07:29,029 --> 00:07:27,000
possibility and those two things we

156
00:07:31,610 --> 00:07:29,039
don't know yet which one is the right

157
00:07:34,070 --> 00:07:31,620
answer the two major things to draw out

158
00:07:36,050 --> 00:07:34,080
of this is just how complex these jets

159
00:07:38,450 --> 00:07:36,060
are because they interact with their

160
00:07:41,029 --> 00:07:38,460
host Galaxy they're not simple they're

161
00:07:44,629 --> 00:07:41,039
not nice smooth outflows the other thing

162
00:07:46,430 --> 00:07:44,639
is that these low power AGM Jets the

163
00:07:48,950 --> 00:07:46,440

Galaxy determines what the Jets look

164

00:07:50,809 --> 00:07:48,960

like to a greater degree than has been

165

00:07:53,270 --> 00:07:50,819

assumed before

166

00:07:56,029 --> 00:07:53,280

I never thought I'd be involved in a

167

00:07:59,270 --> 00:07:56,039

project that uses supercomputer so to me

168

00:08:01,309 --> 00:07:59,280

it was a bit of an alien thing and so I

169

00:08:05,089 --> 00:08:01,319

was fascinated that we actually were

170

00:08:08,330 --> 00:08:05,099

doing this and yes and when I saw the

171

00:08:10,430 --> 00:08:08,340

results that came out I was impressed I

172

00:08:12,409 --> 00:08:10,440

was excited

173

00:08:14,629 --> 00:08:12,419

just a very exciting thing to study

174

00:08:17,280 --> 00:08:14,639

something that is so incredibly new to