2017 Astrobiology Graduate Conference

Charlottesville, VA

1
00:00:00,790 --> 00:00:07,270
[Music]

2
00:00:13,129 --> 00:00:10,190
my name is Scott Soriano I'm a grad

3
00:00:15,169 --> 00:00:13,139
student at at UVA in the Astronomy

4
00:00:17,090 --> 00:00:15,179
Department I just want to thank the

5
00:00:18,320 --> 00:00:17,100
organizers quickly for having a

6
00:00:20,450 --> 00:00:18,330
conference in Charlottesville it's

7
00:00:22,279 --> 00:00:20,460
awesome it's so convenient okay

8
00:00:24,890 --> 00:00:22,289
I also want to thank our previous

9
00:00:26,599 --> 00:00:24,900
speaker Ryan for giving a bunch of

10
00:00:28,460 --> 00:00:26,609
background for for what my talk is gonna

11
00:00:31,400 --> 00:00:28,470
be about I'll just move to the next

12
00:00:32,810 --> 00:00:31,410
slide - awesome okay all right so you

13
00:00:36,350 --> 00:00:32,820

guys already you know all this I'm done

14
00:00:39,380 --> 00:00:36,360
I'll go now right so on the Left we have

15
00:00:45,680 --> 00:00:39,390
HL tau protoplanetary disc on the right

16
00:00:46,970 --> 00:00:45,690
- W Hydra and so again again more

17
00:00:49,430 --> 00:00:46,980
background because you just learned a

18
00:00:52,549 --> 00:00:49,440
bunch of this stuff but these are almond

19
00:00:54,020 --> 00:00:52,559
images around one millimeter continuum

20
00:00:55,700 --> 00:00:54,030
images so what you're actually what

21
00:00:57,470 --> 00:00:55,710
you're seeing is the emission of dust

22
00:00:57,889 --> 00:00:57,480
grains that are about that same size one

23
00:01:00,260 --> 00:00:57,899
milliliter

24
00:01:03,139 --> 00:01:00,270
and TW Hydra on the right is actually

25
00:01:07,010 --> 00:01:03,149
the closest gaseous protoplanetary disc

26
00:01:10,490 --> 00:01:07,020
to the earth so again just all the stuff

27
00:01:12,080 --> 00:01:10,500
but you can get you can get really

28
00:01:13,880 --> 00:01:12,090
resolve really small scales in these

29
00:01:16,760 --> 00:01:13,890
things right so in the top right you can

30
00:01:20,990 --> 00:01:16,770
see you're resolving the the disk

31
00:01:22,310 --> 00:01:21,000
structure down to about one au one thing

32
00:01:24,590 --> 00:01:22,320
that was just briefly mentioned however

33
00:01:27,499 --> 00:01:24,600
not in the previous talk was the fact

34
00:01:30,830 --> 00:01:27,509
that photo planetary discs launch

35
00:01:33,920 --> 00:01:30,840
bipolar outflows and so on the right so

36
00:01:36,140 --> 00:01:33,930
the left again HL tau the right is also

37
00:01:38,240 --> 00:01:36,150
an image of HL tau so they're in the

38
00:01:41,330 --> 00:01:38,250

bottom right of this picture but what

39
00:01:44,840 --> 00:01:41,340
you're seeing here is on a wide angle

40
00:01:46,580 --> 00:01:44,850
wind being launched close to the disc so

41
00:01:47,870 --> 00:01:46,590
it's like this and you see there's a

42
00:01:50,510 --> 00:01:47,880
wind being launched like this and then

43
00:01:53,080 --> 00:01:50,520
you have a very well collimated jet

44
00:01:55,160 --> 00:01:53,090
that's being launched and extends of

45
00:01:58,219 --> 00:01:55,170
quite a long distance actually it's

46
00:02:02,569 --> 00:01:58,229
interacting with the Jets from from

47
00:02:04,639 --> 00:02:02,579
other proto stars in the region and so

48
00:02:06,679 --> 00:02:04,649
just another example of this this is a

49
00:02:10,490 --> 00:02:06,689
pretty famous one this is HH 30 this is

50
00:02:12,110 --> 00:02:10,500
a Hubble image and so on the left

51
00:02:13,940 --> 00:02:12,120
against the disc diameter here is about

52
00:02:15,740 --> 00:02:13,950
200 au and

53
00:02:20,420 --> 00:02:15,750
you can see a very very well collimated

54
00:02:22,250 --> 00:02:20,430
jet being launched up right and then on

55
00:02:24,800 --> 00:02:22,260
the right so this is a over a six year

56
00:02:26,240 --> 00:02:24,810
period through just three images taken

57
00:02:27,500 --> 00:02:26,250
over six year period so you can sort of

58
00:02:30,080 --> 00:02:27,510
see the evolution of the jet you can

59
00:02:32,059 --> 00:02:30,090
even see specific knots in the jet

60
00:02:36,100 --> 00:02:32,069
moving outward as they're launched from

61
00:02:39,949 --> 00:02:36,110
the disk surface so even more recently

62
00:02:42,770 --> 00:02:39,959
another Alma observation one of the best

63
00:02:45,789 --> 00:02:42,780

examples of a wide-angle disc wind being

64
00:02:48,920 --> 00:02:45,799
launched from a protoplanetary disc so

65
00:02:50,300 --> 00:02:48,930
what's actually going on here is it's a

66
00:02:52,250 --> 00:02:50,310
magnetic phenomenon that's that's

67
00:02:58,180 --> 00:02:52,260
launching this extended disc wind up

68
00:03:02,509 --> 00:03:00,800
right what it's called it's called an MH

69
00:03:05,150 --> 00:03:02,519
d disc when MH d is magneto

70
00:03:08,390 --> 00:03:05,160
hydrodynamics the study of the dynamics

71
00:03:10,850 --> 00:03:08,400
of magnetized fluids and so this is a

72
00:03:15,710 --> 00:03:10,860
really good example of a protoplanetary

73
00:03:17,630 --> 00:03:15,720
disc launching a wide-angle wind through

74
00:03:19,670 --> 00:03:17,640
through this magnetic phenomenon that

75
00:03:23,990 --> 00:03:19,680
I'll discuss right now I'll give you

76
00:03:27,349 --> 00:03:24,000
just a quick overview of how the MHD

77
00:03:28,759 --> 00:03:27,359
disc wind disc winds are launched so

78
00:03:31,370 --> 00:03:28,769
here we have it just an edge-on view of

79
00:03:34,000 --> 00:03:31,380
a disc right here is the mid plane of

80
00:03:37,340 --> 00:03:34,010
the disc these solid black lines are

81
00:03:40,400 --> 00:03:37,350
right here they are magnetic field lines

82
00:03:42,080 --> 00:03:40,410
threading the disc vertically and so the

83
00:03:44,449 --> 00:03:42,090
simple concept is just if you have a

84
00:03:46,610 --> 00:03:44,459
magnetic field line threading the disc

85
00:03:49,000 --> 00:03:46,620
it's pointing outward away from the axis

86
00:03:52,309 --> 00:03:49,010
of rotation you can actually launch

87
00:03:53,960 --> 00:03:52,319
material Magneto's are centrifugal II

88
00:03:56,150 --> 00:03:53,970

right you just do force do a force

89
00:03:59,420 --> 00:03:56,160
balance along this line since it's

90
00:04:02,080 --> 00:03:59,430
rotating you actually you just if you've

91
00:04:06,129 --> 00:04:02,090
lift any parcel of gas up off the disc

92
00:04:10,520 --> 00:04:06,139
it can be launched along this field line

93
00:04:12,680 --> 00:04:10,530
and so the idea in ideal MHD so this the

94
00:04:15,349 --> 00:04:12,690
simplest set of equations you can write

95
00:04:19,270 --> 00:04:15,359
down to describe magnetized fluids the

96
00:04:21,500 --> 00:04:19,280
general idea is that the matter then the

97
00:04:23,029 --> 00:04:21,510
matter is completely tied to the

98
00:04:25,640 --> 00:04:23,039
magnetic field so they sort of move

99
00:04:27,409 --> 00:04:25,650
together at the same time and so if you

100
00:04:29,149 --> 00:04:27,419
relax that assumption

101
00:04:30,649 --> 00:04:29,159
equations get a little more complicated

102
00:04:33,140 --> 00:04:30,659
but what happens is you can have the

103
00:04:35,390 --> 00:04:33,150
matter flowing diffusing through the

104
00:04:37,129 --> 00:04:35,400
magnetic fields and so what you have is

105
00:04:39,379 --> 00:04:37,139
you can have a matter creating through

106
00:04:41,089 --> 00:04:39,389
the disk some fraction of the masses are

107
00:04:43,189 --> 00:04:41,099
created onto the central star some

108
00:04:47,659 --> 00:04:43,199
fraction of the mass is launched into

109
00:04:49,040 --> 00:04:47,669
into the disk wind and so how the disk

110
00:04:50,779 --> 00:04:49,050
win actually works like how much mass

111
00:04:53,689 --> 00:04:50,789
you actually lose in the wind compared

112
00:04:56,119 --> 00:04:53,699
to how much you accrete where it's

113
00:04:58,159 --> 00:04:56,129

launched from all depends on disk micro

114
00:05:02,209 --> 00:04:58,169
physics of specifically like the disk

115
00:05:05,149 --> 00:05:02,219
chemistry so it has to do a lot with the

116
00:05:07,820 --> 00:05:05,159
ionization fraction of the disk right so

117
00:05:09,379 --> 00:05:07,830
the low the more ionized the the matter

118
00:05:11,510 --> 00:05:09,389
is the more well couple it is to the

119
00:05:13,879 --> 00:05:11,520
magnetic field and so in the mid plane

120
00:05:15,860 --> 00:05:13,889
of the disk it's actually quite cold

121
00:05:17,990 --> 00:05:15,870
ionization fraction is very low you're

122
00:05:21,950 --> 00:05:18,000
not well coupled to them at a magnetic

123
00:05:24,589 --> 00:05:21,960
field and so as you move up towards the

124
00:05:27,860 --> 00:05:24,599
surface of the disk the stellar light

125
00:05:29,480 --> 00:05:27,870
cellar UV and x-ray photons illuminate

126
00:05:32,059 --> 00:05:29,490
can actually hit the surface of the disk

127
00:05:34,370 --> 00:05:32,069
heating it up therefore increasing your

128
00:05:36,439 --> 00:05:34,380
ionization fraction and that's actually

129
00:05:40,339 --> 00:05:36,449
where the the base of the wind is going

130
00:05:43,010 --> 00:05:40,349
to be launched and then you also have

131
00:05:45,260 --> 00:05:43,020
the disk will be truncated due to the

132
00:05:47,779 --> 00:05:45,270
dust sublimation temperature and also

133
00:05:51,230 --> 00:05:47,789
you might have some gas inside of the

134
00:05:52,249 --> 00:05:51,240
the dust dust disk and that's going to

135
00:05:54,830 --> 00:05:52,259
be truncated by the stellar

136
00:05:59,119 --> 00:05:54,840
magnetosphere so this is going to be

137
00:06:00,860 --> 00:05:59,129
around point 1 au and then maybe the the

138
00:06:05,450 --> 00:06:00,870

gas disc can extend even further to say

139
00:06:07,790 --> 00:06:05,460
0.01 au and so why our disk winds

140
00:06:14,390 --> 00:06:07,800
important well one thing is they they

141
00:06:16,999 --> 00:06:14,400
drive the angular momentum they sorry

142
00:06:19,790 --> 00:06:17,009
they they drive angular momentum

143
00:06:21,649 --> 00:06:19,800
transport in the disk so and in the 90s

144
00:06:24,619 --> 00:06:21,659
it was thought that I was more thought

145
00:06:26,869 --> 00:06:24,629
that um you sort of you can exchange

146
00:06:28,790 --> 00:06:26,879
angular momentum through the disk via

147
00:06:29,930 --> 00:06:28,800
something called the MRI which I want to

148
00:06:33,559 --> 00:06:29,940
talk about but it's just some sort of

149
00:06:35,420 --> 00:06:33,569
magnetized turbulence and so recently if

150
00:06:36,589 --> 00:06:35,430
you actually do some of the complicated

151
00:06:37,939 --> 00:06:36,599
chemistry stuff that I was just talking

152
00:06:40,700 --> 00:06:37,949
about well I didn't talk about the

153
00:06:42,590 --> 00:06:40,710
calculated stuff but if you do some more

154
00:06:45,230 --> 00:06:42,600
tailed models you actually find that the

155
00:06:47,660 --> 00:06:45,240
disc wind actually controls the angular

156
00:06:50,080 --> 00:06:47,670
momentum loss in the disc it controls

157
00:06:52,040 --> 00:06:50,090
the global evolution of the disc and

158
00:06:55,370 --> 00:06:52,050
specifically it controls the global

159
00:06:57,620 --> 00:06:55,380
evolution of the disc on the scales of

160
00:07:00,590 --> 00:06:57,630
the disc where planets are forming so on

161
00:07:02,480 --> 00:07:00,600
the right we can see so this is from

162
00:07:04,220 --> 00:07:02,490
exoplanets or gets pretty cool website I

163
00:07:05,420 --> 00:07:04,230

should check it out but so these are

164
00:07:07,850 --> 00:07:05,430
these are all the exoplanets we have

165
00:07:10,790 --> 00:07:07,860
observed as of last year July of last

166
00:07:13,460 --> 00:07:10,800
year and as you can see down here in the

167
00:07:15,740 --> 00:07:13,470
blue this is where we find most most

168
00:07:17,840 --> 00:07:15,750
exoplanets at least the ones we find

169
00:07:19,850 --> 00:07:17,850
with Kepler most known exoplanets our

170
00:07:22,550 --> 00:07:19,860
good ally in this region right so this

171
00:07:23,840 --> 00:07:22,560
is 0.1 au a tenth of the distance

172
00:07:25,460 --> 00:07:23,850
between the Earth and the Sun so closer

173
00:07:27,590 --> 00:07:25,470
to their host stars and the earth is and

174
00:07:29,210 --> 00:07:27,600
also they're going to be around point l1

175
00:07:31,460 --> 00:07:29,220
Jupiter masses which is like a few Earth

176
00:07:33,980 --> 00:07:31,470
masses so we call them super earth

177
00:07:37,430 --> 00:07:33,990
sometimes mini Neptune's if they have

178
00:07:40,100 --> 00:07:37,440
larger gas envelopes and so the disk

179
00:07:41,840 --> 00:07:40,110
winds are are very important in driving

180
00:07:44,000 --> 00:07:41,850
the global disk evolution right in the

181
00:07:46,220 --> 00:07:44,010
regions where planets are forming and so

182
00:07:49,850 --> 00:07:46,230
it can have a large impact on on what

183
00:07:51,980 --> 00:07:49,860
types of planets can form there and so

184
00:07:53,630 --> 00:07:51,990
the question we wanted to ask was can

185
00:07:55,340 --> 00:07:53,640
disk winds create the radial sub

186
00:07:58,100 --> 00:07:55,350
structures that we we are now observing

187
00:07:59,660 --> 00:07:58,110
in disks can they can can they be

188
00:08:03,470 --> 00:07:59,670

responsible for creating rings and gaps

189
00:08:07,430 --> 00:08:03,480
and protoplanetary disks so I have to

190
00:08:08,870 --> 00:08:07,440
mention that there are other mechanisms

191
00:08:13,510 --> 00:08:08,880
performing them specifically I'll just

192
00:08:17,060 --> 00:08:13,520
mention planets because it's the most

193
00:08:18,740 --> 00:08:17,070
wealth well developed idea that you can

194
00:08:22,220 --> 00:08:18,750
have a large planet sort of carving out

195
00:08:24,830 --> 00:08:22,230
its its own orbit and creating a gap but

196
00:08:27,770 --> 00:08:24,840
there there are a lot of really small

197
00:08:28,820 --> 00:08:27,780
rings too so there might be room for

198
00:08:31,370 --> 00:08:28,830
other things there are some other

199
00:08:35,450 --> 00:08:31,380
mechanisms that I won't that I'll just

200
00:08:38,510 --> 00:08:35,460
move on from though so um right so the

201
00:08:40,550 --> 00:08:38,520
question we want to ask is can MHD disk

202
00:08:43,040 --> 00:08:40,560
winds be responsible chemin it feels be

203
00:08:45,470 --> 00:08:43,050
responsible for creating substructure

204
00:08:47,540 --> 00:08:45,480
and disks and so how do we do how do we

205
00:08:52,250 --> 00:08:47,550
set up this problem well what we do we

206
00:08:53,820 --> 00:08:52,260
do MHD simulations in grid codes so what

207
00:08:57,480 --> 00:08:53,830
we do is we set a

208
00:08:58,800 --> 00:08:57,490
a static grid we define the mass tent

209
00:09:00,840 --> 00:08:58,810
you define all these parameters those

210
00:09:02,790 --> 00:09:00,850
are the MHD equations in the top right

211
00:09:04,920 --> 00:09:02,800
you define all those parameters in each

212
00:09:07,440 --> 00:09:04,930
grid cell in us in these static cells

213
00:09:10,980 --> 00:09:07,450

and as a function of time you evolve

214
00:09:13,680 --> 00:09:10,990
these equations and you can the the

215
00:09:15,930 --> 00:09:13,690
density the magnetic field are affected

216
00:09:19,620 --> 00:09:15,940
through the cells and so you have an

217
00:09:22,920 --> 00:09:19,630
idea of sort of the evolution of the

218
00:09:25,980 --> 00:09:22,930
problem that you're setting up so the

219
00:09:27,870 --> 00:09:25,990
code we use is the Zeus code now on the

220
00:09:29,550 --> 00:09:27,880
bottom right is just an example an

221
00:09:32,580 --> 00:09:29,560
initial setup of of one of our

222
00:09:35,040 --> 00:09:32,590
simulation so again an edge on disk just

223
00:09:36,630 --> 00:09:35,050
one hemisphere but you can see that the

224
00:09:39,210 --> 00:09:36,640
magenta lines are the other magnetic

225
00:09:40,830 --> 00:09:39,220
field that are vertically threading the

226
00:09:46,680 --> 00:09:40,840
disk which is going to allow for the

227
00:09:48,870 --> 00:09:46,690
launching of the winds right and we we

228
00:09:51,600 --> 00:09:48,880
do include one non-ideal effect so that

229
00:09:54,180 --> 00:09:51,610
is saying just that the magnetic field

230
00:09:58,620 --> 00:09:54,190
can that the matter can diffuse through

231
00:10:00,240 --> 00:09:58,630
the magnetic field right so I'm just

232
00:10:01,350 --> 00:10:00,250
gonna hopefully these movies work I'm

233
00:10:03,240 --> 00:10:01,360
just going to show it go right to the

234
00:10:12,410 --> 00:10:03,250
results of the one of the simulations

235
00:10:20,990 --> 00:10:18,949
oh um that's funny it's working out here

236
00:10:23,660 --> 00:10:21,000
I was had to click to the side of the

237
00:10:29,000 --> 00:10:23,670
button on the screen you guys think I'm

238
00:10:31,280 --> 00:10:29,010

just okay I'll try okay so the results

239
00:10:33,050 --> 00:10:31,290
of the simulation we have on the Left we

240
00:10:34,250 --> 00:10:33,060
have the surface density again the the

241
00:10:37,220 --> 00:10:34,260
white lines are magnetic field lines

242
00:10:38,000 --> 00:10:37,230
gray unit vectors are the velocity

243
00:10:39,710 --> 00:10:38,010
components

244
00:10:42,139 --> 00:10:39,720
the ploy Daleville ah sities of the

245
00:10:45,769 --> 00:10:42,149
velocity in the plane of the screen on

246
00:10:48,259 --> 00:10:45,779
the right is a DMD theta which is just

247
00:10:51,470 --> 00:10:48,269
like a sort of a mass flux it's just Rho

248
00:10:52,879 --> 00:10:51,480
times V plus a geometric term so just

249
00:10:54,949 --> 00:10:52,889
think of it as mass flux so if it's red

250
00:10:58,310 --> 00:10:54,959
it's moving outward blue it's moving

251
00:11:04,490 --> 00:10:58,320
inward and on the right is um a face on

252
00:11:05,990 --> 00:11:04,500
view of the surface density again it's

253
00:11:07,579 --> 00:11:06,000
only a 2d simulation so we're assuming

254
00:11:09,620 --> 00:11:07,589
it's actually symmetric here to make

255
00:11:11,900 --> 00:11:09,630
this the third plot but as you can see

256
00:11:15,009 --> 00:11:11,910
materials being is leaving the

257
00:11:17,449 --> 00:11:15,019
simulation domain through the wind

258
00:11:19,100 --> 00:11:17,459
materials in blue as you see in the disk

259
00:11:21,110 --> 00:11:19,110
is being accreted through the disk mid

260
00:11:22,790 --> 00:11:21,120
plane and then on the right you can see

261
00:11:26,660 --> 00:11:22,800
the formation of these these radial

262
00:11:29,060 --> 00:11:26,670
structures the Rings and gas and so I

263
00:11:31,280 --> 00:11:29,070

have a little a little made a little

264
00:11:32,990 --> 00:11:31,290
cartoon to describe the actual mechanism

265
00:11:35,750 --> 00:11:33,000
as to how you are really forming these

266
00:11:37,819 --> 00:11:35,760
rings and gaps in these simulations so

267
00:11:40,340 --> 00:11:37,829
the the idea is that you have you have

268
00:11:42,230 --> 00:11:40,350
matter creating through the disk so you

269
00:11:44,210 --> 00:11:42,240
have some mass accretion rate through

270
00:11:48,019 --> 00:11:44,220
the disk if some mess out flow rate in

271
00:11:50,900 --> 00:11:48,029
the wind I'm so in any one section of

272
00:11:52,550 --> 00:11:50,910
the disk the the magnetic flux in that

273
00:11:55,850 --> 00:11:52,560
section is just proportional to the

274
00:11:59,930 --> 00:11:55,860
vertical magnetic fields there so say

275
00:12:02,059 --> 00:11:59,940
for example you have a magnetic flux

276
00:12:04,130 --> 00:12:02,069
concentration at any one part of the

277
00:12:06,079 --> 00:12:04,140
disk what you're going to do is you can

278
00:12:08,960 --> 00:12:06,089
drive faster accretion through that the

279
00:12:10,970 --> 00:12:08,970
magnetic field applies a torque on the

280
00:12:13,370 --> 00:12:10,980
disk and so you can drive accretion

281
00:12:15,710 --> 00:12:13,380
through that region more efficiently

282
00:12:18,470 --> 00:12:15,720
than before and so you just have a

283
00:12:20,569 --> 00:12:18,480
buildup of mass interior to the gap that

284
00:12:24,110 --> 00:12:20,579
you just created where you'll have a

285
00:12:25,579 --> 00:12:24,120
ring right here and so what you see in

286
00:12:26,269 --> 00:12:25,589
this process is you see this anti

287
00:12:28,069 --> 00:12:26,279
correlation

288
00:12:30,639 --> 00:12:28,079

the surface density of this top plot and

289
00:12:33,439 --> 00:12:30,649
the vertical magnetic field strength

290
00:12:35,269 --> 00:12:33,449
right so in the in the Rings you have

291
00:12:37,550 --> 00:12:35,279
have a lot of mass and you don't have a

292
00:12:39,800 --> 00:12:37,560
lot of magnetic flux again the non-ideal

293
00:12:41,869 --> 00:12:39,810
effects are important here where you can

294
00:12:46,819 --> 00:12:41,879
have matter diffuse through the magnetic

295
00:12:49,340 --> 00:12:46,829
field and then so what you the criterion

296
00:12:52,429 --> 00:12:49,350
you need to form these the Rings and

297
00:12:54,650 --> 00:12:52,439
gaps in these simulations is just that

298
00:12:56,239 --> 00:12:54,660
you need the angular momentum removal

299
00:13:00,439 --> 00:12:56,249
rate which is provided by the magnetic

300
00:13:02,509 --> 00:13:00,449
fields in the wind to to vary as a

301
00:13:04,009 --> 00:13:02,519
function of radius so at any point you

302
00:13:06,949 --> 00:13:04,019
have an over dense you have more

303
00:13:09,439 --> 00:13:06,959
magnetic flux in some region for example

304
00:13:11,600 --> 00:13:09,449
that the mass accretion rate is going to

305
00:13:15,619 --> 00:13:11,610
be proportional to the vertical magnetic

306
00:13:17,509 --> 00:13:15,629
field B Phi or B Z as I had before you

307
00:13:20,600 --> 00:13:17,519
can efficiently clear that region out of

308
00:13:25,519 --> 00:13:20,610
mass and a Cree material just inside of

309
00:13:29,030 --> 00:13:25,529
that gap so another another mechanism

310
00:13:30,410 --> 00:13:29,040
for forming rings in in these

311
00:13:32,540 --> 00:13:30,420
simulations is that you have these

312
00:13:34,490 --> 00:13:32,550
things that we call surface accretion

313
00:13:37,790 --> 00:13:34,500

streams or avalanches as they might have

314
00:13:40,069 --> 00:13:37,800
been called previously the general idea

315
00:13:42,530 --> 00:13:40,079
here is that you have if you have any

316
00:13:44,059 --> 00:13:42,540
pinch on the surface of the pinch in the

317
00:13:45,199 --> 00:13:44,069
magnetic field on the surface of the

318
00:13:48,619 --> 00:13:45,209
disc as you can see our in the outer

319
00:13:51,319 --> 00:13:48,629
region you can drive mass accretion in

320
00:13:53,509 --> 00:13:51,329
this region very very quickly is because

321
00:13:55,639 --> 00:13:53,519
the pinch means that you have a very

322
00:13:57,290 --> 00:13:55,649
strong magnetic field there and so

323
00:13:59,030 --> 00:13:57,300
what's happening is you you're piling

324
00:14:05,059 --> 00:13:59,040
massive very quick through this stream

325
00:14:10,699 --> 00:14:05,069
on to a specific radius 0.5 au here and

326
00:14:12,829 --> 00:14:10,709
so I'll quickly show this happening in

327
00:14:18,860 --> 00:14:12,839
another movie again the same parameters

328
00:14:20,809 --> 00:14:18,870
as the previous movie and so you can see

329
00:14:23,119 --> 00:14:20,819
right here is where the stream is you

330
00:14:26,540 --> 00:14:23,129
have a large mass flux through this

331
00:14:37,930 --> 00:14:26,550
region piling up mass here and that can

332
00:14:44,080 --> 00:14:40,060
so that's a second mechanism for

333
00:14:46,510 --> 00:14:44,090
possibly forming rings and

334
00:14:51,700 --> 00:14:46,520
protoplanetary disks so I only have I

335
00:14:54,310 --> 00:14:51,710
have five seconds left yeah so just to

336
00:14:57,270 --> 00:14:54,320
bring it back to relate it back to the

337
00:14:59,650 --> 00:14:57,280
conference why is this important well

338
00:15:01,960 --> 00:14:59,660

the Rings are going to be dust traps

339
00:15:03,780 --> 00:15:01,970
that's where you could possibly so as

340
00:15:06,700 --> 00:15:03,790
you have dust drifting through the disk

341
00:15:08,290 --> 00:15:06,710
the the high surface density regions are

342
00:15:10,600 --> 00:15:08,300
we also have a pressure maximum and

343
00:15:13,090 --> 00:15:10,610
those pressure maximums can trap

344
00:15:15,820 --> 00:15:13,100
drifting dust grains and possibly that's

345
00:15:19,210 --> 00:15:15,830
where you can grow grow grains and form

346
00:15:23,860 --> 00:15:19,220
planets I'm out of time so I'm just

347
00:15:25,090 --> 00:15:23,870
going to leave that up there so okay

348
00:15:40,140 --> 00:15:25,100
thank you

349
00:15:46,570 --> 00:15:44,260
okay so um quick question on this with

350
00:15:49,990 --> 00:15:46,580
the size scales that you are looking at

351
00:15:52,180 --> 00:15:50,000
so it looked like these simulations that

352
00:15:55,240 --> 00:15:52,190
you're doing are on the the first au

353
00:15:57,190 --> 00:15:55,250
which from the Andrews paper we do see

354
00:15:59,200 --> 00:15:57,200
these sorts of rings on au scales right

355
00:16:01,480 --> 00:15:59,210
but there's also all of the outer rings

356
00:16:03,340 --> 00:16:01,490
so if you looked at how these it look

357
00:16:05,740 --> 00:16:03,350
like in the simulations that they're

358
00:16:07,150 --> 00:16:05,750
kind of propagating outwards how do you

359
00:16:09,070 --> 00:16:07,160
think this would affect the outer disk

360
00:16:11,380 --> 00:16:09,080
and would it propagate all the way out

361
00:16:14,110 --> 00:16:11,390
or are you mainly using this to describe

362
00:16:15,610 --> 00:16:14,120
like those those inner rings that they

363
00:16:18,070 --> 00:16:15,620

see in the Andrews paper right good

364
00:16:19,570 --> 00:16:18,080
question yeah so we initially you pick

365
00:16:21,460 --> 00:16:19,580
these size scales because it was the

366
00:16:23,320 --> 00:16:21,470
planet forming regions where we see a

367
00:16:27,130 --> 00:16:23,330
lot of Kepler planets

368
00:16:28,960 --> 00:16:27,140
and also the the one non ideal MHD

369
00:16:31,450 --> 00:16:28,970
effect is that that's actually where it

370
00:16:33,280 --> 00:16:31,460
is most important in less than one at

371
00:16:34,960 --> 00:16:33,290
you for example and so there are more

372
00:16:36,970 --> 00:16:34,970
effects when you've taken account as we

373
00:16:39,280 --> 00:16:36,980
do the same simulation in the outer

374
00:16:43,780 --> 00:16:39,290
regions of the disk which I was gonna

375
00:16:45,430 --> 00:16:43,790
show thanks for asking but so this is

376
00:16:47,920 --> 00:16:45,440
just included a little bit further out

377
00:16:49,390 --> 00:16:47,930
right so the small scales that I was

378
00:16:52,450 --> 00:16:49,400
showing aren't really that observable

379
00:16:54,570 --> 00:16:52,460
right that was like up to 0.02 au was

380
00:16:56,680 --> 00:16:54,580
was the inner boundary of our simulation

381
00:16:59,680 --> 00:16:56,690
but you can have the same mechanism

382
00:17:01,180 --> 00:16:59,690
happen further out this is some new work

383
00:17:04,450 --> 00:17:01,190
that we're working on with it with a

384
00:17:05,860 --> 00:17:04,460
different non ideal MHD effect and be

385
00:17:08,380 --> 00:17:05,870
polar fusion which will be more

386
00:17:09,330 --> 00:17:08,390
important around 10 au and so that's

387
00:17:18,289 --> 00:17:09,340
something we're looking into