



1  
00:00:11,810 --> 00:00:08,839  
thank you when I was asked to do this

2  
00:00:15,289 --> 00:00:11,820  
talk I really didn't have much idea of

3  
00:00:18,170 --> 00:00:15,299  
how it would fit or who would be

4  
00:00:22,189 --> 00:00:18,180  
listening and so forth and I'm happy to

5  
00:00:26,240 --> 00:00:22,199  
say quite by accident that what I plan

6  
00:00:29,179 --> 00:00:26,250  
to say fits albeit and sometimes curious

7  
00:00:32,540 --> 00:00:29,189  
ways with the talks that have preceded

8  
00:00:36,290 --> 00:00:32,550  
it let me just highlight a couple of

9  
00:00:39,290 --> 00:00:36,300  
those things very quickly one Eric

10  
00:00:42,619 --> 00:00:39,300  
Davis's comment about how when you do

11  
00:00:47,119 --> 00:00:42,629  
advanced propulsion that's beyond the

12  
00:00:49,459 --> 00:00:47,129  
box or beyond what my colleagues in the

13  
00:00:52,790 --> 00:00:49,469

physics department at CSU Fullerton

14

00:00:55,990 --> 00:00:52,800

would think of as normal everyday type

15

00:00:58,220 --> 00:00:56,000

physics you do it very very

16

00:01:02,869 --> 00:00:58,230

conservatively and discreetly and in

17

00:01:04,609 --> 00:01:02,879

small steps the other thing that I would

18

00:01:07,130 --> 00:01:04,619

like to call attention to is that when

19

00:01:09,230 --> 00:01:07,140

you do this sort of thing as York Dobyns

20

00:01:11,929 --> 00:01:09,240

has pointed out you want to be sure that

21

00:01:13,940 --> 00:01:11,939

you're doing real physics because it's

22

00:01:16,609 --> 00:01:13,950

easy to delude yourself into thinking

23

00:01:19,789 --> 00:01:16,619

that something might be serious physics

24

00:01:25,940 --> 00:01:19,799

and it turns out that it's not so my

25

00:01:28,660 --> 00:01:25,950

talk I suspect the headline title from

26

00:01:32,179 --> 00:01:28,670

Stephen Hawking's recent thing on TV

27

00:01:33,969 --> 00:01:32,189

reaching out to the stars because that's

28

00:01:39,830 --> 00:01:33,979

primarily what I want to talk about

29

00:01:42,770 --> 00:01:39,840

today or if for the past 15 years really

30

00:01:44,660 --> 00:01:42,780

I've been doing the small steps trying

31

00:01:48,830 --> 00:01:44,670

to keep it on it's physics and all of

32

00:01:50,569 --> 00:01:48,840

that but in the early days when I was

33

00:01:53,359 --> 00:01:50,579

figuring out what I thought might be

34

00:01:56,060 --> 00:01:53,369

going on it was clear to me that there

35

00:01:58,160 --> 00:01:56,070

was more to it than simply small scale

36

00:02:01,570 --> 00:01:58,170

thrusters that vibrate and do weird

37

00:02:04,060 --> 00:02:01,580

things and stuff like that about

38

00:02:06,360 --> 00:02:04,070

I was invited to give it well I was

39

00:02:09,580 --> 00:02:06,370

invited to John Kramer 75th birthday

40

00:02:11,950 --> 00:02:09,590

symposium and when I told John that I'd

41

00:02:14,260 --> 00:02:11,960

come he suggested that I should give a

42

00:02:16,800 --> 00:02:14,270

talk and I availed myself of the

43

00:02:19,300 --> 00:02:16,810

opportunity to start talking about what

44

00:02:21,850 --> 00:02:19,310

I'm going to spend part of my time on

45

00:02:24,010 --> 00:02:21,860

today than experimental stuff but there

46

00:02:26,410 --> 00:02:24,020

is some experimental stuff that is say

47

00:02:33,600 --> 00:02:26,420

reality doesn't pinch on some of this a

48

00:02:37,000 --> 00:02:33,610

bit okay serious advanced professional

49

00:02:39,220 --> 00:02:37,010

in the modern world really starts with

50

00:02:41,860 --> 00:02:39,230

this guy here it's a picture of Kip

51  
00:02:43,840 --> 00:02:41,870  
Thorne Caltech Fineman professor of

52  
00:02:48,100 --> 00:02:43,850  
theoretical physics at Caltech for many

53  
00:02:51,090 --> 00:02:48,110  
years now recently retired this is from

54  
00:02:54,550 --> 00:02:51,100  
the time at which he did his

55  
00:02:56,350 --> 00:02:54,560  
epoch-making papers on wormholes which

56  
00:03:00,460 --> 00:02:56,360  
you've heard discussed earlier today

57  
00:03:02,590 --> 00:03:00,470  
that is so around 1987 or 88

58  
00:03:04,330 --> 00:03:02,600  
I'm not going to revisit the story of

59  
00:03:07,120 --> 00:03:04,340  
how he came to do that because of his

60  
00:03:11,199 --> 00:03:07,130  
buddy Carl Sagan I am going to show you

61  
00:03:13,300 --> 00:03:11,209  
the abstract of his paper okay he tried

62  
00:03:16,540 --> 00:03:13,310  
to present this as a pedagogical tool

63  
00:03:19,030 --> 00:03:16,550

for teaching general relativity of

64

00:03:20,710 --> 00:03:19,040

course nobody knew nobody figured that

65

00:03:24,220 --> 00:03:20,720

that what he was what he was really up

66

00:03:27,220 --> 00:03:24,230

to debated in an appendix to his paper

67

00:03:30,070 --> 00:03:27,230

is this and this is the reason why Eric

68

00:03:33,190 --> 00:03:30,080

earlier this morning and others have

69

00:03:36,520 --> 00:03:33,200

commented that you need other levy otic

70

00:03:39,750 --> 00:03:36,530

amounts of negative west mass material

71

00:03:44,380 --> 00:03:39,760

in order to do anything like so-called

72

00:03:47,500 --> 00:03:44,390

al-kabir what drives or traversable

73

00:03:50,080 --> 00:03:47,510

wormholes indeed that is what you need

74

00:03:53,590 --> 00:03:50,090

in order to produce what is what they

75

00:03:55,420 --> 00:03:53,600

call an absurdly benign wormhole it

76

00:03:58,600 --> 00:03:55,430

turns out that you can use smaller

77

00:04:02,380 --> 00:03:58,610

amounts than a Jupiter mass of negative

78

00:04:04,750 --> 00:04:02,390

West mass matter to produce a one hell

79

00:04:07,180 --> 00:04:04,760

throat but if it's less than the Jupiter

80

00:04:09,039 --> 00:04:07,190

mass for most interesting configurations

81

00:04:09,640 --> 00:04:09,049

they're going to get throat flowing

82

00:04:12,940 --> 00:04:09,650

that's

83

00:04:15,520 --> 00:04:12,950

up everything for miles around okay so

84

00:04:19,390 --> 00:04:15,530

it really is on the order of a

85

00:04:22,810 --> 00:04:19,400

jupiter-mass of- rest mass manner in say

86

00:04:25,210 --> 00:04:22,820

sphere on the order of say 40 meters in

87

00:04:27,249 --> 00:04:25,220

diameter with a ray of thickness on the

88

00:04:29,740 --> 00:04:27,259

order of maybe a meter or so plus or

89

00:04:31,659 --> 00:04:29,750

minus event know what and if you do the

90

00:04:34,120 --> 00:04:31,669

calculation you find out that turns out

91

00:04:37,029 --> 00:04:34,130

to be much much much higher than nuclear

92

00:04:39,730 --> 00:04:37,039

densities of that sort of stuff I'm

93

00:04:42,310 --> 00:04:39,740

going to show you the obligatory

94

00:04:44,260 --> 00:04:42,320

pictures that have been produced for

95

00:04:46,270 --> 00:04:44,270

this this is the wormhole that Eric

96

00:04:48,400 --> 00:04:46,280

showed you a different version of this

97

00:04:51,460 --> 00:04:48,410

actually to my knowledge first appeared

98

00:04:54,610 --> 00:04:51,470

in Morris in Mizner Thorne and wheelers

99

00:04:58,240 --> 00:04:54,620

book on gravitation back in 1973

100

00:05:00,670 --> 00:04:58,250

published in 73 by Freeman and it was

101

00:05:03,189 --> 00:05:00,680

primarily that the instigation of mr.

102

00:05:05,020 --> 00:05:03,199

and Thorne's doctoral dissertation

103

00:05:08,640 --> 00:05:05,030

supervisor John Wheeler that it was

104

00:05:11,589 --> 00:05:08,650

included this is the world bowl a

105

00:05:15,600 --> 00:05:11,599

hyperspace embedding diagram that you've

106

00:05:19,810 --> 00:05:15,610

seen this is a recent rendition of a

107

00:05:23,110 --> 00:05:19,820

warp drive ship that's shown up on the

108

00:05:27,129 --> 00:05:23,120

web and so on this is for one of Stephen

109

00:05:30,969 --> 00:05:27,139

Hawking's illustrated books a spaceship

110

00:05:33,430 --> 00:05:30,979

in the act of producing negative rest

111

00:05:35,680 --> 00:05:33,440

mass matter and the ring and inducing in

112

00:05:40,000 --> 00:05:35,690

a warm oil throat through which it is

113

00:05:43,360 --> 00:05:40,010

about to proceed this is from nineteen

114

00:05:46,000 --> 00:05:43,370

no not 19 2002 Scientific American

115

00:05:49,060 --> 00:05:46,010

summer issue I think one of those it's

116

00:05:51,700 --> 00:05:49,070

it's what is referred to in the trade

117

00:05:56,230 --> 00:05:51,710

now as a Stargate but it is is really

118

00:06:00,100 --> 00:05:56,240

short throat wormhole ok spiracle in

119

00:06:02,409 --> 00:06:00,110

this case one of the people who I have a

120

00:06:04,270 --> 00:06:02,419

virtual group of folks who look over my

121

00:06:07,270 --> 00:06:04,280

shoulder or throw rocks from time to

122

00:06:09,510 --> 00:06:07,280

time and stuff like that and remember

123

00:06:11,460 --> 00:06:09,520

well dreamy if you were looking

124

00:06:13,020 --> 00:06:11,470

carefully enteric slides you would have

125

00:06:15,390 --> 00:06:13,030

found that he was one of the authors in

126

00:06:18,270 --> 00:06:15,400

one of the articles and book that they

127

00:06:20,850 --> 00:06:18,280

edited okay men go put this together for

128

00:06:23,309 --> 00:06:20,860

me about a month ago or so when I made

129

00:06:26,779 --> 00:06:23,319

some comment about infringing copyrights

130

00:06:29,670 --> 00:06:26,789

and that I was worried about that okay

131

00:06:33,749 --> 00:06:29,680

in order to get the right perspective on

132

00:06:35,850 --> 00:06:33,759

this and it's always no actually the

133

00:06:38,159 --> 00:06:35,860

real reason for this is this is the best

134

00:06:42,740 --> 00:06:38,169

Calvin and Hobbes cartoon I've ever seen

135

00:07:14,450 --> 00:06:42,750

it's posted in my laboratory okay

136

00:07:23,780 --> 00:07:18,680

okay now with that as preparation you

137

00:07:27,800 --> 00:07:23,790

need to be shorting serious skepticism

138

00:07:29,120 --> 00:07:27,810

is required in this business okay okay

139

00:07:31,820 --> 00:07:29,130

what does it take to do this so

140

00:07:33,950 --> 00:07:31,830

jupiter-mass of- rest mass matter okay

141

00:07:35,240 --> 00:07:33,960

that's really basically what you've got

142

00:07:37,160 --> 00:07:35,250

to do and what i want to talk about

143

00:07:38,600 --> 00:07:37,170

today i'll tell you a little bit about

144

00:07:40,280 --> 00:07:38,610

the experimental work that I've been

145

00:07:43,910 --> 00:07:40,290

doing later on but what I want to talk

146

00:07:46,730 --> 00:07:43,920

about today is this because what often

147

00:07:50,060 --> 00:07:46,740

passes for conversation about this this

148

00:07:52,580 --> 00:07:50,070

is a point which I think is important

149

00:07:55,190 --> 00:07:52,590

and just to remind you how much a

150

00:07:59,260 --> 00:07:55,200

jupiter-mass of matter is it's 2 times

151

00:08:01,640 --> 00:07:59,270

10 to the 27th kilograms of stuff that's

152

00:08:04,040 --> 00:08:01,650

600 times the mass of the earth or

153

00:08:07,130 --> 00:08:04,050

something it's a very large amount of

154

00:08:10,490 --> 00:08:07,140

mass okay is there any chance that this

155

00:08:13,520 --> 00:08:10,500

can be done and especially using only

156

00:08:17,390 --> 00:08:13,530

low and by low I mean the best we can

157

00:08:20,480 --> 00:08:17,400

possibly produce they are all low energy

158

00:08:22,370 --> 00:08:20,490

electromagnetic fields because in this

159

00:08:23,620 --> 00:08:22,380

business electromagnetic fields are

160

00:08:26,480 --> 00:08:23,630

pretty much what you're limited to

161

00:08:31,220 --> 00:08:26,490

steams the other option and steam power

162

00:08:34,550 --> 00:08:31,230

isn't obviously yeah okay where do you

163

00:08:37,370 --> 00:08:34,560

get a Jupiter mass of exotic matter okay

164

00:08:40,070 --> 00:08:37,380

remember this has to be rest mass matter

165

00:08:40,880 --> 00:08:40,080

stuff that you can stop in laboratory

166

00:08:42,830 --> 00:08:40,890

okay

167

00:08:44,600 --> 00:08:42,840

not stuff that's zipping along at the

168

00:08:46,400 --> 00:08:44,610

speed of light I suppose you could

169

00:08:48,770 --> 00:08:46,410

contain it in something or something

170

00:08:51,710 --> 00:08:48,780

like that but rest mass matter is the

171

00:08:55,370 --> 00:08:51,720

stuff that Morrison thorne we're talking

172

00:08:58,280 --> 00:08:55,380

about the usual story and when you see

173

00:09:00,500 --> 00:08:58,290

stuff on this topic on TV what people

174

00:09:03,910 --> 00:09:00,510

usually talk about is by amplifying

175

00:09:06,860 --> 00:09:03,920

Planck scale wormholes presumably

176

00:09:10,010 --> 00:09:06,870

quantum gravity which doesn't exist yet

177

00:09:12,620 --> 00:09:10,020

the theory doesn't exist yet nonetheless

178

00:09:14,750 --> 00:09:12,630

suggests that space-time form at the

179

00:09:16,520 --> 00:09:14,760

Planck scale occurs and that there are

180

00:09:19,079 --> 00:09:16,530

wormholes flitting into and out of

181

00:09:21,299 --> 00:09:19,089

existence at that scale and so forth

182

00:09:23,819 --> 00:09:21,309

and the idea here and this was by the

183

00:09:26,220 --> 00:09:23,829

way proposed by Thoren himself in his

184

00:09:29,220 --> 00:09:26,230

early papers on this is that somehow you

185

00:09:31,230 --> 00:09:29,230

get really super small quantum tweezers

186

00:09:32,970 --> 00:09:31,240

and grab one of these Planck scale

187

00:09:35,549 --> 00:09:32,980

wormholes and then you stretch it out

188

00:09:39,569 --> 00:09:35,559

and amplify it whatever that means

189

00:09:43,710 --> 00:09:39,579

of to macroscopic dimensions oops wrong

190

00:09:46,170 --> 00:09:43,720

way okay here we go next one another

191

00:09:48,329 --> 00:09:46,180

suggestions have been made is that there

192

00:09:51,869 --> 00:09:48,339

may be naturally-occurring exotic matter

193

00:09:53,639 --> 00:09:51,879

cosmic strings remnants from the initial

194

00:09:55,739 --> 00:09:53,649

creation of the universe and stuff like

195

00:09:57,689 --> 00:09:55,749

that and then if you motor around in

196

00:10:01,439 --> 00:09:57,699

deep space and identify some of this

197

00:10:03,210 --> 00:10:01,449

stuff and put it your tractor beam on it

198

00:10:07,199 --> 00:10:03,220

and drive it around and so on you might

199

00:10:09,809 --> 00:10:07,209

be able to do that okay by figuring out

200

00:10:12,150 --> 00:10:09,819

how to transform normal matter into

201  
00:10:17,129 --> 00:10:12,160  
exotic matter this may sound to you like

202  
00:10:19,280 --> 00:10:17,139  
the least likely that and I must admit I

203  
00:10:22,920 --> 00:10:19,290  
didn't think it was very likely either

204  
00:10:25,079 --> 00:10:22,930  
but I should point out as Peter Maloney

205  
00:10:27,809 --> 00:10:25,089  
pointed out to me many years ago and a

206  
00:10:30,600 --> 00:10:27,819  
delightful conversation about all of

207  
00:10:33,269 --> 00:10:30,610  
this stuff he said you realize of course

208  
00:10:36,480 --> 00:10:33,279  
that in quantum electrodynamics the bare

209  
00:10:40,110 --> 00:10:36,490  
masses of elementary particles are

210  
00:10:42,569 --> 00:10:40,120  
negative and an infinite they have to be

211  
00:10:44,790 --> 00:10:42,579  
because the renormalization program in

212  
00:10:47,809 --> 00:10:44,800  
effect adds positive infinite energy

213  
00:10:57,689 --> 00:10:47,819

that trusses it down to a finite value

214

00:11:01,049 --> 00:10:57,699

okay that's this okay question is how do

215

00:11:04,139 --> 00:11:01,059

you undress elementary particles and in

216

00:11:05,790 --> 00:11:04,149

the standard view of the standard model

217

00:11:08,129 --> 00:11:05,800

of quantum mechanics the answer to that

218

00:11:11,939 --> 00:11:08,139

is you don't okay because the

219

00:11:14,059 --> 00:11:11,949

fluctuation process that produces the

220

00:11:17,189 --> 00:11:14,069

cloud of virtual photons and electrons

221

00:11:18,860 --> 00:11:17,199

Ron pairs is not something that you can

222

00:11:23,610 --> 00:11:18,870

manipulate using low-energy

223

00:11:25,460 --> 00:11:23,620

electromagnetic fields okay the question

224

00:11:27,140 --> 00:11:25,470

then arises in the reason

225

00:11:29,660 --> 00:11:27,150

why Melanie and I were talking about

226

00:11:31,970 --> 00:11:29,670

this many years ago was because I was

227

00:11:34,910 --> 00:11:31,980

interested in the Thai at the time in

228

00:11:36,230 --> 00:11:34,920

the question of how do gravity and

229

00:11:39,290 --> 00:11:36,240

inertia and all of this stuff

230

00:11:41,870 --> 00:11:39,300

interrelate and what do elementary

231

00:11:43,760 --> 00:11:41,880

particles look like it was obvious I

232

00:11:45,650 --> 00:11:43,770

wasn't going to invent quantum gravity

233

00:11:48,650 --> 00:11:45,660

there are a lot smarter people than me

234

00:11:52,460 --> 00:11:48,660

who've spent lifetimes trying to do that

235

00:11:55,760 --> 00:11:52,470

and having not succeeded so I went

236

00:11:58,430 --> 00:11:55,770

looking at general relativistic semi

237

00:12:01,070 --> 00:11:58,440

classical and classical models of the

238

00:12:02,930 --> 00:12:01,080

electron elementary particles and it

239

00:12:05,720 --> 00:12:02,940

turns out there's this cottage industry

240

00:12:08,120 --> 00:12:05,730

in this there are a bunch of people out

241

00:12:10,910 --> 00:12:08,130

there who at least used to sit around

242

00:12:13,340 --> 00:12:10,920

working out various models for

243

00:12:15,140 --> 00:12:13,350

elementary particles there are some

244

00:12:16,670 --> 00:12:15,150

requirements that you're going to want

245

00:12:19,670 --> 00:12:16,680

if you're interested in gravity and

246

00:12:22,310 --> 00:12:19,680

inertia it should include gravity is

247

00:12:24,620 --> 00:12:22,320

gratifi gravity modification is

248

00:12:28,100 --> 00:12:24,630

something that will likely be involved

249

00:12:30,770 --> 00:12:28,110

okay and it should be exact so that

250

00:12:32,810 --> 00:12:30,780

approximations don't cloud any issues in

251

00:12:34,610 --> 00:12:32,820

other words you want to theory that

252

00:12:36,470 --> 00:12:34,620

people aren't going to look at saying oh

253

00:12:38,900 --> 00:12:36,480

that's just an approximation that's all

254

00:12:44,450 --> 00:12:38,910

just a lot of nonsense if you can get it

255

00:12:45,620 --> 00:12:44,460

okay the people there suddenly off on

256

00:12:48,560 --> 00:12:45,630

the track that I'm going to tell you

257

00:12:51,290 --> 00:12:48,570

about briefly now was published around

258

00:12:53,720 --> 00:12:51,300

1990 in the New York Academy of Sciences

259

00:12:56,450 --> 00:12:53,730

it was a review article by a by ashtekar

260

00:12:59,090 --> 00:12:56,460

on his work on what he called new

261

00:13:02,210 --> 00:12:59,100

hamiltonian variables for general

262

00:13:04,430 --> 00:13:02,220

relativity his attempt at a quantum

263

00:13:07,820 --> 00:13:04,440

theory of gravity which at the time

264

00:13:10,250 --> 00:13:07,830

around 1990 was very fashionable I was

265

00:13:12,440 --> 00:13:10,260

informed last fall at the Cramer

266

00:13:15,260 --> 00:13:12,450

symposium by somebody who does this

267

00:13:17,900 --> 00:13:15,270

stuff that ashtekar view on this is no

268

00:13:21,620 --> 00:13:17,910

longer considered viable which may or

269

00:13:23,720 --> 00:13:21,630

may not be the case but ashtekar singled

270

00:13:28,270 --> 00:13:23,730

out that was a particular interest to me

271

00:13:32,510 --> 00:13:28,280

was several pages later and that is that

272

00:13:35,930 --> 00:13:32,520

1960 Arnold wit deser and Misner ADM as

273

00:13:37,630 --> 00:13:35,940

they're referred to had constructed an

274

00:13:40,430 --> 00:13:37,640

exact

275

00:13:43,280 --> 00:13:40,440

relativistic general relativistic not

276  
00:13:45,500 --> 00:13:43,290  
special relativistic model of elementary

277  
00:13:48,290 --> 00:13:45,510  
particles because they found the

278  
00:13:51,260 --> 00:13:48,300  
solution for cloud spherical cloud of

279  
00:13:54,260 --> 00:13:51,270  
charged dust okay and it turns out that

280  
00:13:57,410 --> 00:13:54,270  
you can do this as a schtick or lays it

281  
00:14:00,890 --> 00:13:57,420  
out here and let me see if I think AHA

282  
00:14:04,010 --> 00:14:00,900  
wait a second am i pushing the right

283  
00:14:07,130 --> 00:14:04,020  
thing yes okay this is a result you come

284  
00:14:09,080 --> 00:14:07,140  
to in general relativity of course you

285  
00:14:11,480 --> 00:14:09,090  
can't treat the mass and Newtonian

286  
00:14:14,810 --> 00:14:11,490  
fashion so when you get this equation

287  
00:14:16,550 --> 00:14:14,820  
here you have to treat that as a an

288  
00:14:19,160 --> 00:14:16,560

equation if you're solving for M is

289

00:14:22,070 --> 00:14:19,170

quadratic in M you apply the standard

290

00:14:24,710 --> 00:14:22,080

formula you get this and then as a shtak

291

00:14:27,920 --> 00:14:24,720

are pointed out if you let R go to 0 or

292

00:14:30,320 --> 00:14:27,930

R is actually epsilon in this article

293

00:14:32,900 --> 00:14:30,330

what you find is that some of the terms

294

00:14:35,450 --> 00:14:32,910

go to 0 but you end up with a finite

295

00:14:37,580 --> 00:14:35,460

result ok and you didn't have to

296

00:14:39,530 --> 00:14:37,590

enormous anything you didn't have to

297

00:14:41,600 --> 00:14:39,540

fudge you didn't have to wave your hands

298

00:14:44,150 --> 00:14:41,610

or anything like that you automatically

299

00:14:46,280 --> 00:14:44,160

get a finite result when you include

300

00:14:49,550 --> 00:14:46,290

both electromagnetism and gravity in

301  
00:14:52,970 --> 00:14:49,560  
this fashion ok the problem of course is

302  
00:14:54,110 --> 00:14:52,980  
as this is called the ADM mass turns out

303  
00:14:56,450 --> 00:14:54,120  
to be a square root of the

304  
00:14:58,790 --> 00:14:56,460  
fine-structure constant smaller than the

305  
00:15:01,730 --> 00:14:58,800  
Planck mass okay which is 10 to the

306  
00:15:04,130 --> 00:15:01,740  
minus fifth grams which is obviously not

307  
00:15:07,670 --> 00:15:04,140  
the mass of any elementary particle with

308  
00:15:09,850 --> 00:15:07,680  
which we're familiar ok this is an

309  
00:15:14,270 --> 00:15:09,860  
enlargement at the bottom of that slide

310  
00:15:20,180 --> 00:15:14,280  
ok it has some positive features but it

311  
00:15:23,410 --> 00:15:20,190  
has some drawbacks it's too big the

312  
00:15:27,170 --> 00:15:23,420  
simple bare mass of the ADM electron is

313  
00:15:30,110 --> 00:15:27,180

positive and what we know is that the

314

00:15:32,240 --> 00:15:30,120

bale mass should be negative ok or at

315

00:15:35,030 --> 00:15:32,250

least if you take the standard model

316

00:15:37,330 --> 00:15:35,040

seriously it should be negative the

317

00:15:41,420 --> 00:15:37,340

question is what happens if you put in a

318

00:15:43,700 --> 00:15:41,430

negative bear mass in the ADM mono ok

319

00:15:47,270 --> 00:15:43,710

gravitation only Andrews has a local

320

00:15:48,300 --> 00:15:47,280

self energy in the ADM model that is to

321

00:15:50,850 --> 00:15:48,310

say no account

322

00:15:53,940 --> 00:15:50,860

has taken of coupling to the distant

323

00:15:58,350 --> 00:15:53,950

matter in the universe okay now for

324

00:16:01,950 --> 00:15:58,360

reasons other than anything having to do

325

00:16:03,570 --> 00:16:01,960

with this back at the time that I was

326

00:16:05,400 --> 00:16:03,580

fiddling around with us it had already

327

00:16:07,950 --> 00:16:05,410

occurred to me that you needed to take

328

00:16:10,050 --> 00:16:07,960

machs principle seriously if you were

329

00:16:15,060 --> 00:16:10,060

going to get very far in advanced

330

00:16:17,190 --> 00:16:15,070

propulsion okay there is an interesting

331

00:16:19,590 --> 00:16:17,200

thing about the ADM mass however a

332

00:16:22,290 --> 00:16:19,600

difference from the electron mass by

333

00:16:25,890 --> 00:16:22,300

almost exactly the square of the speed

334

00:16:29,070 --> 00:16:25,900

like it's to within ten percent which

335

00:16:31,740 --> 00:16:29,080

tells you something well it may be just

336

00:16:34,190 --> 00:16:31,750

a coincidence and it may be a red

337

00:16:38,160 --> 00:16:34,200

herring but there may be something there

338

00:16:41,130 --> 00:16:38,170

if you take machs principle seriously

339

00:16:43,260 --> 00:16:41,140

what you discover is that the value of

340

00:16:46,530 --> 00:16:43,270

the total scale or gravitational

341

00:16:48,870 --> 00:16:46,540

potential is C squared which suggests

342

00:16:53,280 --> 00:16:48,880

that maybe this has something to do with

343

00:16:56,070 --> 00:16:53,290

the ATM mass okay and that if you take

344

00:16:58,020 --> 00:16:56,080

into consideration machs principle you

345

00:17:01,110 --> 00:16:58,030

might be able to get back a realistic

346

00:17:03,120 --> 00:17:01,120

value for the electron mass okay the

347

00:17:06,800 --> 00:17:03,130

bare mass should be negative as I said

348

00:17:10,230 --> 00:17:06,810

and what does all of this lead to well

349

00:17:12,300 --> 00:17:10,240

if you're interested in finding out the

350

00:17:14,699 --> 00:17:12,310

details I'll be happy to read a pointer

351  
00:17:16,730 --> 00:17:14,709  
to paper said I've already published or

352  
00:17:19,490 --> 00:17:16,740  
if you like I'll be happy to send you a

353  
00:17:22,230 --> 00:17:19,500  
manuscript that's presently in progress

354  
00:17:26,699 --> 00:17:22,240  
that spells out all of this stuff about

355  
00:17:29,280 --> 00:17:26,709  
the ADM s what you wind up with when you

356  
00:17:31,140 --> 00:17:29,290  
take a negative bear mass and you insist

357  
00:17:33,510 --> 00:17:31,150  
that the equivalence principle be

358  
00:17:36,180 --> 00:17:33,520  
correct that is to say that when the

359  
00:17:38,550 --> 00:17:36,190  
gravitational mass of an object is

360  
00:17:41,610 --> 00:17:38,560  
negative its inertial mass has to be

361  
00:17:44,820 --> 00:17:41,620  
negative - okay this is by the way a

362  
00:17:47,880 --> 00:17:44,830  
mistake that is made by actually some

363  
00:17:50,400 --> 00:17:47,890

rather surprising folks they when you

364

00:17:53,550 --> 00:17:50,410

drop a negative biomass off when you

365

00:17:55,620 --> 00:17:53,560

drop a negative mass object in the

366

00:17:57,390 --> 00:17:55,630

Earth's gravitational field you will

367

00:17:58,070 --> 00:17:57,400

hear people who want to know better say

368

00:18:00,470 --> 00:17:58,080

that it's for

369

00:18:02,750 --> 00:18:00,480

held and therefore go so the fact of the

370

00:18:04,759 --> 00:18:02,760

matter is that it falls just like normal

371

00:18:08,360 --> 00:18:04,769

mass because while the force is

372

00:18:10,039 --> 00:18:08,370

repulsive the emotional reaction to the

373

00:18:13,009 --> 00:18:10,049

repulsive forces to make the thing

374

00:18:15,019 --> 00:18:13,019

accelerate downward okay if that weren't

375

00:18:17,149 --> 00:18:15,029

so the equivalence principle would be

376

00:18:20,360 --> 00:18:17,159

first general relativity would be wrong

377

00:18:23,000 --> 00:18:20,370

and Libreville and deep trouble okay

378

00:18:25,490 --> 00:18:23,010

because it's a metric nature of general

379

00:18:28,159 --> 00:18:25,500

relativity that allows you to talk

380

00:18:30,289 --> 00:18:28,169

seriously about wormholes and stargates

381

00:18:32,509 --> 00:18:30,299

and stuff like that advanced propulsion

382

00:18:35,990 --> 00:18:32,519

wouldn't be nearly as much fun

383

00:18:39,560 --> 00:18:36,000

if general relativity were wrong okay

384

00:18:40,879 --> 00:18:39,570

let me point out here that let's push

385

00:18:42,830 --> 00:18:40,889

the wrong button sorry

386

00:18:47,120 --> 00:18:42,840

oops that's the wrong direction here we

387

00:18:50,149 --> 00:18:47,130

are okay this is the total gravitational

388

00:18:54,259 --> 00:18:50,159

potential due to the universe as a value

389

00:18:58,009 --> 00:18:54,269

of C squared up to some numerical factor

390

00:18:59,960 --> 00:18:58,019

of order unity this is the potential due

391

00:19:03,049 --> 00:18:59,970

to the cloud of electrically charged

392

00:19:05,149 --> 00:19:03,059

dust it has negative bear mass so this

393

00:19:07,100 --> 00:19:05,159

is a negative potential this is a

394

00:19:09,259 --> 00:19:07,110

positive potential when you add those

395

00:19:12,409 --> 00:19:09,269

things together they're both equal to

396

00:19:15,049 --> 00:19:12,419

about C squared what you end up with is

397

00:19:17,269 --> 00:19:15,059

this thing dominating the denominator

398

00:19:21,860 --> 00:19:17,279

and that gives you back the electron

399

00:19:24,649 --> 00:19:21,870

mass okay up to orders a up two factors

400

00:19:27,379 --> 00:19:24,659

of order unity to within ten percent of

401  
00:19:31,490 --> 00:19:27,389  
you fudge or lose order unity numbers

402  
00:19:36,230 --> 00:19:31,500  
right what okay if you could figure out

403  
00:19:38,720 --> 00:19:36,240  
how to suppress this this will make

404  
00:19:41,750 --> 00:19:38,730  
longer be cancelled in effect by an

405  
00:19:43,669 --> 00:19:41,760  
equal and opposite potential and what

406  
00:19:46,610 --> 00:19:43,679  
you would end up with is this thing

407  
00:19:49,940 --> 00:19:46,620  
being a hoarder unity and you would end

408  
00:19:52,039 --> 00:19:49,950  
up with the ADM mass being exposed the

409  
00:19:55,779 --> 00:19:52,049  
bare hands of the elementary particles

410  
00:19:59,029 --> 00:19:55,789  
and as you work out the algebra for

411  
00:20:02,629 --> 00:19:59,039  
arithmetic for this what you discover is

412  
00:20:03,680 --> 00:20:02,639  
that if you have a sphere 30 meters in

413  
00:20:07,010 --> 00:20:03,690

diameter about

414

00:20:08,810 --> 00:20:07,020

metre thick of normal stuff and you

415

00:20:11,240 --> 00:20:08,820

figure out how to suppress this thing

416

00:20:15,800 --> 00:20:11,250

here this thing turns it into a

417

00:20:18,680 --> 00:20:15,810

jupiter-mass of- rest mass matter okay

418

00:20:22,220 --> 00:20:18,690

so when principal if there's anything to

419

00:20:25,460 --> 00:20:22,230

this and i emphasize if there's anything

420

00:20:29,720 --> 00:20:25,470

to this in principle you should be able

421

00:20:33,700 --> 00:20:29,730

to make jupiter masses of negative rest

422

00:20:36,080 --> 00:20:33,710

mass matter to produce wormholes and

423

00:20:41,930 --> 00:20:36,090

both drives and all the rest of that

424

00:20:44,720 --> 00:20:41,940

okay if this is right okay how do you do

425

00:20:52,120 --> 00:20:44,730

it well by making feasts of MU c feasts

426  
00:20:56,440 --> 00:20:52,130  
of you small or zero okay can it be done

427  
00:21:01,090 --> 00:20:56,450  
with low energy electromagnetic fields

428  
00:21:06,140 --> 00:21:01,100  
how that's where Marx principle comes in

429  
00:21:08,990 --> 00:21:06,150  
okay that by the way is here in smock

430  
00:21:12,950 --> 00:21:09,000  
and his study I believe it was around

431  
00:21:14,870 --> 00:21:12,960  
1888 or thereabouts in Vienna hey what

432  
00:21:20,510 --> 00:21:14,880  
does max principle you push on something

433  
00:21:24,200 --> 00:21:20,520  
it pushes back that well people who used

434  
00:21:26,540 --> 00:21:24,210  
to argue about this but if you look at

435  
00:21:28,670 --> 00:21:26,550  
the physics of it you can say the

436  
00:21:32,720 --> 00:21:28,680  
gravitational action of distant stuff

437  
00:21:34,520 --> 00:21:32,730  
out there okay now as you've heard there

438  
00:21:37,700 --> 00:21:34,530

are many different versions of machs

439

00:21:40,250 --> 00:21:37,710

principle indeed the subtlety of the

440

00:21:43,010 --> 00:21:40,260

distinctions in some cases becomes

441

00:21:45,050 --> 00:21:43,020

almost illusory and all that and people

442

00:21:48,830 --> 00:21:45,060

used to fight about this quite

443

00:21:51,740 --> 00:21:48,840

vehemently at times okay but this guy

444

00:21:54,620 --> 00:21:51,750

here in his doctoral work with Paul

445

00:21:57,770 --> 00:21:54,630

Dirac back in the early 1950s at Stennis

446

00:22:01,460 --> 00:21:57,780

Shyama died about five years ago okay in

447

00:22:03,080 --> 00:22:01,470

a few lines showed in a vector theory of

448

00:22:05,750 --> 00:22:03,090

gravitation which is of course only

449

00:22:08,990 --> 00:22:05,760

approximation to general relativity but

450

00:22:11,270 --> 00:22:09,000

nonetheless at the time Shyama thought

451

00:22:12,200 --> 00:22:11,280

it wasn't general relativity it's turned

452

00:22:15,500 --> 00:22:12,210

out that it

453

00:22:18,980 --> 00:22:15,510

general relativity in disguise okay it

454

00:22:22,580 --> 00:22:18,990

turns out that if you take the gravity

455

00:22:24,850 --> 00:22:22,590

electric field to be the analog of the

456

00:22:28,730 --> 00:22:24,860

electric field in electrodynamics and

457

00:22:30,470 --> 00:22:28,740

then you ask what a is the vector part

458

00:22:33,170 --> 00:22:30,480

of the four potential further

459

00:22:36,560 --> 00:22:33,180

gravitational field it turns out to be

460

00:22:39,890 --> 00:22:36,570

the integral of matter currents over all

461

00:22:42,530 --> 00:22:39,900

space and all that Shyama used a neat

462

00:22:44,810 --> 00:22:42,540

trick here so that you don't get

463

00:22:47,930 --> 00:22:44,820

involved in lengthy tedious calculations

464

00:22:50,270 --> 00:22:47,940

involving lots of algebra okay he said

465

00:22:52,520 --> 00:22:50,280

hey look if you look at an object and

466

00:22:54,680 --> 00:22:52,530

it's being accelerated it looks to that

467

00:22:56,510 --> 00:22:54,690

object as if the universe is rigidly

468

00:22:59,750 --> 00:22:56,520

being accelerated in the opposite

469

00:23:01,910 --> 00:22:59,760

direction okay so you can take  $V$  out of

470

00:23:03,290 --> 00:23:01,920

the integral here and I only have to do

471

00:23:06,680 --> 00:23:03,300

is integrate over the matter density

472

00:23:09,290 --> 00:23:06,690

okay when you do the integration over

473

00:23:12,170 --> 00:23:09,300

the matter density to get a what you

474

00:23:15,110 --> 00:23:12,180

find is that you get just the scalar

475

00:23:18,530 --> 00:23:15,120

gravitational potential okay

476

00:23:23,990 --> 00:23:18,540

so the gravity electric field end up

477

00:23:27,950 --> 00:23:24,000

being minus the gradient of  $\phi$  minus  $V$

478

00:23:30,950 --> 00:23:27,960

over  $C$  squared times the time derivative

479

00:23:33,910 --> 00:23:30,960

of the velocity of the object if the

480

00:23:37,100 --> 00:23:33,920

velocity is constant that term is zero

481

00:23:39,290 --> 00:23:37,110

okay if the velocity is not constant

482

00:23:42,790 --> 00:23:39,300

that is to say if it's being accelerated

483

00:23:49,100 --> 00:23:42,800

of course then that term is not zero and

484

00:23:50,900 --> 00:23:49,110

if the term in front of it the factor in

485

00:23:53,300 --> 00:23:50,910

front of it  $\phi$  over  $C$  squared is equal

486

00:23:56,150 --> 00:23:53,310

to one it turns out to be the inertial

487

00:23:59,990 --> 00:23:56,160

reaction force okay it's as simple as

488

00:24:03,980 --> 00:24:00,000

that what this means is that in any

489

00:24:06,370 --> 00:24:03,990

theory of gravity where you have so

490

00:24:09,740 --> 00:24:06,380

called critical cosmic matter density

491

00:24:12,920 --> 00:24:09,750

okay which is characterized by space

492

00:24:15,940 --> 00:24:12,930

being flattened okay fee turns out to

493

00:24:18,680 --> 00:24:15,950

have that property it turns out that

494

00:24:21,620 --> 00:24:18,690

emotional reaction forces in general

495

00:24:24,419 --> 00:24:21,630

relativity are provided by the

496

00:24:27,299 --> 00:24:24,429

gravitational action of distant matter

497

00:24:30,239 --> 00:24:27,309

since the what w map results we know

498

00:24:33,450 --> 00:24:30,249

that space is flat okay it's as simple

499

00:24:35,549 --> 00:24:33,460

as that now of course there scads and

500

00:24:37,619 --> 00:24:35,559

scads of people who don't care or it

501  
00:24:40,080 --> 00:24:37,629  
don't pay attention and don't know this

502  
00:24:41,519 --> 00:24:40,090  
okay but this isn't a matter of

503  
00:24:44,509 --> 00:24:41,529  
something that you can really argue

504  
00:24:47,310 --> 00:24:44,519  
about anymore where ten years ago it was

505  
00:24:49,970 --> 00:24:47,320  
okay that's nice but how does this help

506  
00:24:53,369 --> 00:24:49,980  
with a jupiter mass of exotic matter

507  
00:24:58,529 --> 00:24:53,379  
okay well we need to ask about local

508  
00:25:01,769 --> 00:24:58,539  
sources of the field okay

509  
00:25:05,820 --> 00:25:01,779  
part of getting a part of advancing

510  
00:25:08,730 --> 00:25:05,830  
middle age yes you become less concerned

511  
00:25:10,950 --> 00:25:08,740  
about covering your tracks and more

512  
00:25:13,470 --> 00:25:10,960  
concerned about making sure people get

513  
00:25:15,749 --> 00:25:13,480

what you're trying to say and hopefully

514

00:25:17,909 --> 00:25:15,759

that they will have interesting

515

00:25:21,509 --> 00:25:17,919

criticisms because you can learn from

516

00:25:22,859 --> 00:25:21,519

that if you just wave your hands and all

517

00:25:28,460 --> 00:25:22,869

the rest of that and they don't get it

518

00:25:33,149 --> 00:25:31,080

before I got interested mocks prince

519

00:25:34,799 --> 00:25:33,159

will not really but before I got

520

00:25:38,340 --> 00:25:34,809

seriously interested in machs principle

521

00:25:40,950 --> 00:25:38,350

I was interested in theories that

522

00:25:43,440 --> 00:25:40,960

coupled gravity and electromagnetism in

523

00:25:47,220 --> 00:25:43,450

ways other than the naive

524

00:25:49,289 --> 00:25:47,230

Einstein Maxwell equations okay one of

525

00:25:51,060 --> 00:25:49,299

those was a suggestion by Arthur

526

00:25:53,909 --> 00:25:51,070

Schuster back around the turn of the

527

00:25:56,759 --> 00:25:53,919

19th 20th century which had been

528

00:25:59,549 --> 00:25:56,769

followed up by Patrick black at the 1947

529

00:26:02,940 --> 00:25:59,559

Nobel laureate in physics for work on

530

00:26:04,950 --> 00:26:02,950

cosmic rays that rotating neutral mass

531

00:26:07,529 --> 00:26:04,960

of objects might generate magnetic

532

00:26:09,810 --> 00:26:07,539

fields rule magnetic fields not gravity

533

00:26:13,470 --> 00:26:09,820

tow magnetic fields a real magnetic

534

00:26:17,970 --> 00:26:13,480

field a fellow who was then a graduate

535

00:26:20,279 --> 00:26:17,980

student in Ontario Canada named George

536

00:26:22,320 --> 00:26:20,289

Luke who I believe ended up as a

537

00:26:25,200 --> 00:26:22,330

professor of Electrical Engineering at

538

00:26:27,029 --> 00:26:25,210

Princeton for most of his career okay

539

00:26:30,239 --> 00:26:27,039

sat down wrote out a set of coupled

540

00:26:33,180 --> 00:26:30,249

field equations to go with Blackett

541

00:26:35,720 --> 00:26:33,190

hypothesis published in canadian journal

542

00:26:38,990 --> 00:26:35,730

of physics 1953

543

00:26:40,790 --> 00:26:39,000

from his paper okay those are the couple

544

00:26:45,290 --> 00:26:40,800

field equations that give you back the

545

00:26:48,050 --> 00:26:45,300

Schuster pocket effect okay new track

546

00:26:50,540 --> 00:26:48,060

wasn't interested in the details of

547

00:26:53,060 --> 00:26:50,550

general relativity so when he did was he

548

00:26:57,010 --> 00:26:53,070

wrote down his coupled field equations

549

00:26:58,840 --> 00:26:57,020

as the four-dimensional formalism being

550

00:27:00,980 --> 00:26:58,850

electrodynamics maxwellian

551  
00:27:03,880 --> 00:27:00,990  
electrodynamics and then he used his

552  
00:27:06,260 --> 00:27:03,890  
fifth dimension to include a

553  
00:27:08,380 --> 00:27:06,270  
relativistically invariant version of

554  
00:27:12,050 --> 00:27:08,390  
Newtonian gravity that's these three

555  
00:27:17,090 --> 00:27:12,060  
equations here okay the one that's of

556  
00:27:20,480 --> 00:27:17,100  
interest here looks very very much like

557  
00:27:25,540 --> 00:27:20,490  
this equation up here well similar

558  
00:27:28,970 --> 00:27:25,550  
anyway oops wrong direction okay okay

559  
00:27:32,210 --> 00:27:28,980  
the standard equation to stand alone

560  
00:27:34,880 --> 00:27:32,220  
some very an equation for a propagating

561  
00:27:38,180 --> 00:27:34,890  
field of course is one where you have

562  
00:27:41,120 --> 00:27:38,190  
the divergence of the force plus one

563  
00:27:43,820 --> 00:27:41,130

over C squared times the time derivative

564

00:27:46,010 --> 00:27:43,830

us the field and so on is equal to the

565

00:27:50,810 --> 00:27:46,020

sources the D'Alembert's sign of the field

566

00:27:53,930 --> 00:27:50,820

is equal to its sources okay so if you

567

00:27:56,360 --> 00:27:53,940

look at this term here that turns out to

568

00:27:59,180 --> 00:27:56,370

be the rate at which the field does work

569

00:28:01,190 --> 00:27:59,190

on its sources cute it turns out to be

570

00:28:03,790 --> 00:28:01,200

that and in fact there's a good reason

571

00:28:07,640 --> 00:28:03,800

for that as you can discover by reading

572

00:28:09,490 --> 00:28:07,650

Wolfgang's winners outstanding little book

573

00:28:13,220 --> 00:28:09,500

on introduction to special relativity

574

00:28:16,820 --> 00:28:13,230

okay and you will find in section 35

575

00:28:18,470 --> 00:28:16,830

this little discussion here okay for

576

00:28:21,230 --> 00:28:18,480

example if two particles collide

577

00:28:25,850 --> 00:28:21,240

elastically their rest masses during

578

00:28:27,950 --> 00:28:25,860

collision will vary okay that might be

579

00:28:30,500 --> 00:28:27,960

when you're interested in them and then

580

00:28:32,720 --> 00:28:30,510

he develops his formalism unfortunately

581

00:28:34,790 --> 00:28:32,730

it was only laid out this clearly in the

582

00:28:36,260 --> 00:28:34,800

second edition which was after I had

583

00:28:36,920 --> 00:28:36,270

struggled through all of this stuff

584

00:28:39,740 --> 00:28:36,930

myself

585

00:28:43,320 --> 00:28:39,750

okay and wasn't quite sure that it was

586

00:28:48,600 --> 00:28:43,330

right it turns out that it is okay

587

00:28:53,010 --> 00:28:48,610

what three pages of algebra gets you

588

00:28:56,250 --> 00:28:53,020

from that aha that's where the three

589

00:28:57,570 --> 00:28:56,260

pages of algebra okay basically what you

590

00:29:00,030 --> 00:28:57,580

do is you ask yourself the following

591

00:29:03,060 --> 00:29:00,040

question if an inertial reaction force

592

00:29:05,070 --> 00:29:03,070

is indeed being generated by the

593

00:29:08,490 --> 00:29:05,080

gravitational field due to the distant

594

00:29:11,640 --> 00:29:08,500

matter in the universe okay what happens

595

00:29:13,350 --> 00:29:11,650

as you would accelerate the object you

596

00:29:16,740 --> 00:29:13,360

can just simply ask what are the local

597

00:29:20,850 --> 00:29:16,750

sources of the field and if you take  $F$

598

00:29:22,440 --> 00:29:20,860

the for vector  $F$  here as being divided

599

00:29:24,720 --> 00:29:22,450

by the mass of the object that's being

600

00:29:26,880 --> 00:29:24,730

accelerated as the field in question

601  
00:29:30,090 --> 00:29:26,890  
then I can simply sit down and calculate

602  
00:29:34,380 --> 00:29:30,100  
using this expression for the full force

603  
00:29:37,760 --> 00:29:34,390  
what that has to be three pages of

604  
00:29:40,440 --> 00:29:37,770  
algebra get you there

605  
00:29:42,780 --> 00:29:40,450  
okay the data motion of the field is

606  
00:29:45,150 --> 00:29:42,790  
equal to what we normally think of as a

607  
00:29:47,010 --> 00:29:45,160  
sources plus a bunch of transient terms

608  
00:29:49,980 --> 00:29:47,020  
and the thing that I want to emphasize

609  
00:29:54,120 --> 00:29:49,990  
for you here is if there is no hand

610  
00:29:56,280 --> 00:29:54,130  
waving involved this is really to be

611  
00:30:01,340 --> 00:29:56,290  
perfectly honest about it undergraduate

612  
00:30:05,550 --> 00:30:01,350  
level physics this isn't some esoteric

613  
00:30:08,790 --> 00:30:05,560

thing like that okay what that ends up

614

00:30:11,310 --> 00:30:08,800

with is the equation that York Dobyns

615

00:30:13,830 --> 00:30:11,320

showed you earlier this morning and then

616

00:30:15,720 --> 00:30:13,840

pointed out that it comes to it makes

617

00:30:18,350 --> 00:30:15,730

some predictions if treated in a fairly

618

00:30:21,030 --> 00:30:18,360

straightforward naive way that are

619

00:30:23,880 --> 00:30:21,040

dubious to say the least

620

00:30:26,130 --> 00:30:23,890

okay but you end up with is this

621

00:30:29,070 --> 00:30:26,140

equation and notice it has two parts

622

00:30:31,830 --> 00:30:29,080

the linear term which is the one that he

623

00:30:35,160 --> 00:30:31,840

was talking about produces enormous

624

00:30:37,530 --> 00:30:35,170

effects you can engineer situations

625

00:30:40,080 --> 00:30:37,540

where you can get really in principle

626

00:30:42,060 --> 00:30:40,090

and practices turns out to be a

627

00:30:44,430 --> 00:30:42,070

different matter but in principle you

628

00:30:47,220 --> 00:30:44,440

can produce very large effects with that

629

00:30:48,580 --> 00:30:47,230

term indeed so large that if you can

630

00:30:50,710 --> 00:30:48,590

figure out how to do it

631

00:30:52,840 --> 00:30:50,720

you can make thrusters that you should

632

00:30:54,399 --> 00:30:52,850

be able to sell to NASA because you're

633

00:30:56,740 --> 00:30:54,409

not blowing any propellant out the

634

00:30:59,080 --> 00:30:56,750

tailpipe you're gravitationally coupling

635

00:31:01,600 --> 00:30:59,090

directly to the rest of the universe and

636

00:31:04,299 --> 00:31:01,610

so on and so forth you have to put

637

00:31:05,980 --> 00:31:04,309

energy and to do this but you don't have

638

00:31:08,730 --> 00:31:05,990

to worry about carrying along a lot of

639

00:31:11,980 --> 00:31:08,740

stuff that goes out the tailpipe okay

640

00:31:14,049 --> 00:31:11,990

but I'm going to emphasize today however

641

00:31:16,750 --> 00:31:14,059

is this term oops

642

00:31:19,690 --> 00:31:16,760

I keep pushing the wrong button this

643

00:31:24,279 --> 00:31:19,700

term here notice that it's smaller by a

644

00:31:28,990 --> 00:31:24,289

factor of C squared then this thing here

645

00:31:32,860 --> 00:31:29,000

the coefficient of the power terms P is

646

00:31:35,769 --> 00:31:32,870

a power IV for a capacitor or something

647

00:31:38,440 --> 00:31:35,779

like that this by the way is not voltage

648

00:31:41,080 --> 00:31:38,450

that's the volume notice that the first

649

00:31:42,669 --> 00:31:41,090

term is independent of the volume of

650

00:31:45,100 --> 00:31:42,679

whatever you're doing but this one turns

651  
00:31:47,289 --> 00:31:45,110  
out to be a density so you have to get

652  
00:31:50,529 --> 00:31:47,299  
high densities in order to make this

653  
00:31:53,139 --> 00:31:50,539  
term large the really interesting thing

654  
00:31:55,630 --> 00:31:53,149  
about this term is that there's a minus

655  
00:31:59,230 --> 00:31:55,640  
sign in front of it and everything else

656  
00:32:04,029 --> 00:31:59,240  
is squared or positive okay that means

657  
00:32:06,159 --> 00:32:04,039  
that term is always negative okay and as

658  
00:32:07,810 --> 00:32:06,169  
a result we call it the wormhole Terr me

659  
00:32:13,149 --> 00:32:07,820  
and my group of virtual

660  
00:32:14,830 --> 00:32:13,159  
over-the-shoulder lookers okay it turns

661  
00:32:17,289 --> 00:32:14,840  
out you can do a crude numerical

662  
00:32:19,930 --> 00:32:17,299  
integration and you discover that with

663  
00:32:23,399 --> 00:32:19,940

reasonable assumptions that you can

664

00:32:27,669 --> 00:32:23,409

transiently by cycling the first term

665

00:32:30,250 --> 00:32:27,679

here so that  $\rho = 0$  which occurs in the

666

00:32:34,120 --> 00:32:30,260

denominator of these coefficients can be

667

00:32:35,950 --> 00:32:34,130

driven to zero when the coefficient is 0

668

00:32:38,980 --> 00:32:35,960

in the denominator the coefficient

669

00:32:41,320 --> 00:32:38,990

becomes infinite of course formally that

670

00:32:44,049 --> 00:32:41,330

means that this term here normally a

671

00:32:47,049 --> 00:32:44,059

factor of  $C^2$  smaller than the

672

00:32:50,529 --> 00:32:47,059

leading term dominates the equation and

673

00:32:52,800 --> 00:32:50,539

in principle you ought to be able if

674

00:32:54,930 --> 00:32:52,810

there's anything to all of this

675

00:32:57,720 --> 00:32:54,940

in principle you ought to be able to

676

00:33:00,150 --> 00:32:57,730

make idiotic amounts of negative rest

677

00:33:03,780 --> 00:33:00,160

mass matter that is Sailor Jupiter

678

00:33:06,540 --> 00:33:03,790

masses in reasonable size structures and

679

00:33:09,210 --> 00:33:06,550

since this is a process which is induced

680

00:33:11,400 --> 00:33:09,220

in situ you won't have to worry about

681

00:33:14,970 --> 00:33:11,410

collecting a bunch of stuff and trying

682

00:33:18,050 --> 00:33:14,980

to compact it down into your 30 meter of

683

00:33:20,400 --> 00:33:18,060

diameter sphere it's already there

684

00:33:23,520 --> 00:33:20,410

because you and me and everything else

685

00:33:26,550 --> 00:33:23,530

in the world has this lurking inside of

686

00:33:30,840 --> 00:33:26,560

our elementary particles the negative

687

00:33:32,580 --> 00:33:30,850

rest mass is already there okay okay now

688

00:33:34,500 --> 00:33:32,590

the question is is there anything to

689

00:33:36,870 --> 00:33:34,510

this at all and the answer to that

690

00:33:39,480 --> 00:33:36,880

question is if it doesn't get supported

691

00:33:41,880 --> 00:33:39,490

by experiments convincing experiments

692

00:33:43,290 --> 00:33:41,890

the answer is nobody's gonna pay any

693

00:33:44,970 --> 00:33:43,300

attention to it then we're not paying

694

00:33:48,450 --> 00:33:44,980

any attention to it anyway but that's

695

00:33:50,460 --> 00:33:48,460

their problem not yours my problem is to

696

00:33:53,970 --> 00:33:50,470

see if there's anything to this well and

697

00:33:56,070 --> 00:33:53,980

indeed following this this is from an

698

00:33:57,930 --> 00:33:56,080

earlier presentation where I was talking

699

00:34:02,630 --> 00:33:57,940

about small steps and all that but I'll

700

00:34:05,820 --> 00:34:02,640

show it to you anyway okay what you do

701  
00:34:08,190 --> 00:34:05,830  
is you try and induce a fluctuation and

702  
00:34:10,169 --> 00:34:08,200  
push on the object when you're making

703  
00:34:12,149 --> 00:34:10,179  
the thing a little bit more massive and

704  
00:34:15,810 --> 00:34:12,159  
pull back on it when it's a little bit

705  
00:34:19,919 --> 00:34:15,820  
less massive this is the linear analogue

706  
00:34:23,840 --> 00:34:19,929  
of york's wheel okay fair enough fair

707  
00:34:26,880 --> 00:34:23,850  
enough okay

708  
00:34:28,950 --> 00:34:26,890  
this is number build Rainey's animation

709  
00:34:34,139 --> 00:34:28,960  
for a presentation that he did that I

710  
00:34:36,090 --> 00:34:34,149  
got from him okay it's a really much

711  
00:34:39,180 --> 00:34:36,100  
cleverer than anything I could have come

712  
00:34:41,250 --> 00:34:39,190  
up with okay is there any other didn't

713  
00:34:44,850 --> 00:34:41,260

says well let's suggest that this might

714

00:34:47,190 --> 00:34:44,860

be right okay I'm gonna tell you a

715

00:34:50,010 --> 00:34:47,200

little bit and how am i doing on time do

716

00:34:52,849 --> 00:34:50,020

it well then it's okay

717

00:34:56,359 --> 00:34:52,859

five minutes quickly

718

00:34:59,359 --> 00:34:56,369

okay the experiment that I'm working on

719

00:35:00,829 --> 00:34:59,369

now implements an idea of a former

720

00:35:03,799 --> 00:35:00,839

graduate student of mine which is

721

00:35:07,150 --> 00:35:03,809

basically to take some active material

722

00:35:10,069 --> 00:35:07,160

which are going to drive with a

723

00:35:12,049 --> 00:35:10,079

alternating voltage which will produce a

724

00:35:13,999 --> 00:35:12,059

sort of internal energy fluctuations

725

00:35:17,539 --> 00:35:14,009

that should produce mass fluctuations

726  
00:35:19,900 --> 00:35:17,549  
one may coincide with an acceleration a

727  
00:35:23,089 --> 00:35:19,910  
mistake that we made including myself

728  
00:35:25,940 --> 00:35:23,099  
for a long time was to assume that you

729  
00:35:27,829 --> 00:35:25,950  
could just simply apply an AC voltage to

730  
00:35:30,049 --> 00:35:27,839  
a capacitor and you should induce mass

731  
00:35:32,809 --> 00:35:30,059  
fluctuation if there isn't any bulk

732  
00:35:34,940 --> 00:35:32,819  
acceleration present there's no mass

733  
00:35:37,059 --> 00:35:34,950  
fluctuation and the reason why is

734  
00:35:39,589 --> 00:35:37,069  
because when you construct the equation

735  
00:35:41,420 --> 00:35:39,599  
to which you get the transient terms

736  
00:35:43,609 --> 00:35:41,430  
from you assume that your bulk

737  
00:35:47,150 --> 00:35:43,619  
accelerating the thing that has the

738  
00:35:50,359 --> 00:35:47,160

energy change taking place okay the

739

00:35:53,479 --> 00:35:50,369

other ends of these are also piezo

740

00:35:55,699 --> 00:35:53,489

electric actuators in this case their

741

00:35:58,329 --> 00:35:55,709

polarities are set up this way so when

742

00:36:01,099 --> 00:35:58,339

you apply a voltage to them one of them

743

00:36:03,559 --> 00:36:01,109

contracts the other expands it basically

744

00:36:07,339 --> 00:36:03,569

shuttles the material in between back

745

00:36:10,900 --> 00:36:07,349

and forth then all you do is apply there

746

00:36:13,969 --> 00:36:10,910

is one of these devices sitting between

747

00:36:15,979 --> 00:36:13,979

clamping blocks here aluminum clamping

748

00:36:18,170 --> 00:36:15,989

blocks on the end of a very very

749

00:36:21,019 --> 00:36:18,180

sensitive torsion balance which I'll get

750

00:36:24,109 --> 00:36:21,029

to in a moment what you do is you apply

751

00:36:26,859 --> 00:36:24,119

a voltage to the capacitative material

752

00:36:30,410 --> 00:36:26,869

in between and you apply another voltage

753

00:36:33,559 --> 00:36:30,420

which has two components run at the

754

00:36:35,809 --> 00:36:33,569

frequency of the applied voltage to the

755

00:36:39,199 --> 00:36:35,819

so-called capacitor up here what I'm

756

00:36:41,479 --> 00:36:39,209

calling a capacitor to accelerate it to

757

00:36:45,019 --> 00:36:41,489

produce your so-called bulk acceleration

758

00:36:47,569 --> 00:36:45,029

and a second double frequency signal

759

00:36:49,819 --> 00:36:47,579

because the mass fluctuation and

760

00:36:51,559 --> 00:36:49,829

allegedly occurs at the power frequency

761

00:36:53,749 --> 00:36:51,569

of what you're doing and that of course

762

00:36:55,640 --> 00:36:53,759

is the product of a couple of sine and a

763

00:36:57,829 --> 00:36:55,650

cosine or whatever that gives you a

764

00:37:00,170 --> 00:36:57,839

double frequency signal and then you

765

00:37:01,930 --> 00:37:00,180

have to provide for phase shifting and

766

00:37:04,480 --> 00:37:01,940

locking and stuff like that

767

00:37:06,550 --> 00:37:04,490

okay bunch of technical details this is

768

00:37:11,079 --> 00:37:06,560

more or less what the device looks like

769

00:37:14,170 --> 00:37:11,089

okay the reason why this these are see

770

00:37:17,800 --> 00:37:14,180

flex flexural bearings supporting these

771

00:37:19,750 --> 00:37:17,810

torsion balance so on that was because

772

00:37:23,050 --> 00:37:19,760

of nimble bulge Ernie's use of Martin

773

00:37:25,930 --> 00:37:23,060

Tamar's truss balance which looks like

774

00:37:28,480 --> 00:37:25,940

this okay similar to this at any rate

775

00:37:31,510 --> 00:37:28,490

okay there's a counterweight over here

776

00:37:34,270 --> 00:37:31,520

to counterweight the device there are

777

00:37:36,490 --> 00:37:34,280

some calibration coils here so that you

778

00:37:38,349 --> 00:37:36,500

can calibrate the system the really

779

00:37:41,589 --> 00:37:38,359

important part of this device is right

780

00:37:43,660 --> 00:37:41,599

here coaxial with the flexural bearings

781

00:37:45,579 --> 00:37:43,670

here you have a set of Galan stand

782

00:37:48,190 --> 00:37:45,589

contacts because you're putting a fair

783

00:37:50,500 --> 00:37:48,200

amount of power on the order of ten or

784

00:37:52,630 --> 00:37:50,510

fifteen or twenty watts through these

785

00:37:55,300 --> 00:37:52,640

contacts and if you're trying to measure

786

00:37:58,359 --> 00:37:55,310

things on the order of ten to a hundred

787

00:38:00,640 --> 00:37:58,369

nano Newton's you've got to be extremely

788

00:38:02,470 --> 00:38:00,650

careful about stuff like this because

789

00:38:05,650 --> 00:38:02,480

it's real easy to mask what you're

790

00:38:07,480 --> 00:38:05,660

looking for with spurious stuff okay

791

00:38:11,710 --> 00:38:07,490

this is a close-up of the gallant stand

792

00:38:14,589 --> 00:38:11,720

contacts this is I especially like yes

793

00:38:18,490 --> 00:38:14,599

one minute this picture of it okay real

794

00:38:19,839 --> 00:38:18,500

quickly results from January the way in

795

00:38:21,910 --> 00:38:19,849

which you do this is you turn the whole

796

00:38:23,920 --> 00:38:21,920

thing one that's what happens you just

797

00:38:26,800 --> 00:38:23,930

wait a second pushing the wrong button

798

00:38:29,020 --> 00:38:26,810

that's what happens here that offset is

799

00:38:31,240 --> 00:38:29,030

just an electrical offset basically what

800

00:38:33,430 --> 00:38:31,250

you do when you turn on the power is you

801

00:38:35,680 --> 00:38:33,440

shift the ground level in the system

802

00:38:39,400 --> 00:38:35,690

because of ground return currents and

803

00:38:41,319 --> 00:38:39,410

all what okay the red trace here is an

804

00:38:43,000 --> 00:38:41,329

accelerometer in the middle of the stack

805

00:38:45,819 --> 00:38:43,010

which tells you what's going on in the

806

00:38:48,160 --> 00:38:45,829

stack the blue trace is the position

807

00:38:49,540 --> 00:38:48,170

sensor an optical position sensor so

808

00:38:51,790 --> 00:38:49,550

that it doesn't get the electromagnetic

809

00:38:53,800 --> 00:38:51,800

pick up and so forth and as you can see

810

00:38:56,849 --> 00:38:53,810

when you turn it on the thing does this

811

00:39:00,280 --> 00:38:56,859

when you flip a switch and reverse

812

00:39:03,609 --> 00:39:00,290

invert the phase of the actuator signal

813

00:39:06,700 --> 00:39:03,619

what happens is the thrust changes and

814

00:39:08,740 --> 00:39:06,710

that should not happen if there is no

815

00:39:10,840 --> 00:39:08,750

effect present okay

816

00:39:12,040 --> 00:39:10,850

and then when you turn flip it back it

817

00:39:15,070 --> 00:39:12,050

goes back and so on

818

00:39:17,800 --> 00:39:15,080

okay and for a while late in January and

819

00:39:20,910 --> 00:39:17,810

early in February opps time to shut up

820

00:39:24,280 --> 00:39:20,920

huh take two seconds okay

821

00:39:26,140 --> 00:39:24,290

quickly as possible these are the sort

822

00:39:28,510 --> 00:39:26,150

of traces you're getting what I'm

823

00:39:30,910 --> 00:39:28,520

showing you is reality what happens in

824

00:39:33,220 --> 00:39:30,920

reality as you can see things are

825

00:39:35,500 --> 00:39:33,230

beginning to gray do a little bit the

826

00:39:37,420 --> 00:39:35,510

height of this thing here isn't the same

827

00:39:39,640 --> 00:39:37,430

as the height of this thing here which

828

00:39:41,830 --> 00:39:39,650

means that you have thermal evolution in

829

00:39:46,000 --> 00:39:41,840

this region here where the thing is one

830

00:39:48,640 --> 00:39:46,010

there's major thermal evolution okay and

831

00:39:50,410 --> 00:39:48,650

this is catastrophic thermal evolution

832

00:39:53,170 --> 00:39:50,420

and after this happened the device never

833

00:39:54,880 --> 00:39:53,180

worked that way again okay which is not

834

00:39:56,650 --> 00:39:54,890

good news from the point of view of

835

00:39:58,960 --> 00:39:56,660

continuing to fiddle around with it but

836

00:40:01,510 --> 00:39:58,970

it is good news from one point of view

837

00:40:03,280 --> 00:40:01,520

it tells you immediately that a whole

838

00:40:05,710 --> 00:40:03,290

bunch of spurious things that you might

839

00:40:08,260 --> 00:40:05,720

have to investigate or not the cause of

840

00:40:09,850 --> 00:40:08,270

the signal you're looking at okay after

841

00:40:10,480 --> 00:40:09,860

a few months of fooling around with no

842

00:40:12,550 --> 00:40:10,490

device

843

00:40:14,200 --> 00:40:12,560

there it is wired there it is on the end

844

00:40:18,610 --> 00:40:14,210

of the balance there's some neat stuff

845

00:40:20,350 --> 00:40:18,620

more stuff and that's the trace that was

846

00:40:22,090 --> 00:40:20,360

to be the beginning of a series of

847

00:40:24,220 --> 00:40:22,100

traces that I would have told you about

848

00:40:28,030 --> 00:40:24,230

in great detail here today instead of

849

00:40:32,350 --> 00:40:28,040

wormholes and negative mass matter the

850

00:40:34,720 --> 00:40:32,360

power amplifier died right there that's

851

00:40:38,560 --> 00:40:34,730

a transient of the power amplifier dying

852

00:40:43,690 --> 00:40:38,570

at which word I decided these are signal

853

00:40:47,230 --> 00:40:43,700

generators okay okay and now I there is

854

00:40:50,550 --> 00:40:47,240

no time for questions I assume yes there

855

00:40:53,860 --> 00:40:50,560

is there are a few minutes for questions

856

00:40:56,830 --> 00:40:53,870

okay and I will recuse myself from

857

00:40:59,200 --> 00:40:56,840

asking anything because dr. Woodward and

858

00:41:00,700 --> 00:40:59,210

I have had a sort of indirect

859

00:41:02,800 --> 00:41:00,710

correspondence on a number of these

860

00:41:11,140 --> 00:41:02,810

topics

861

00:41:13,210 --> 00:41:11,150

for hours yes if a nursery is viewed as

862

00:41:14,470 --> 00:41:13,220

a reaction from the rest of the universe

863

00:41:16,030 --> 00:41:14,480

then how does that happen

864

00:41:19,120 --> 00:41:16,040

instantaneously for any kind of

865

00:41:20,410 --> 00:41:19,130

acceleration that's why John Kramer and

866

00:41:22,780 --> 00:41:20,420

I are really good friends

867

00:41:25,060 --> 00:41:22,790

it's a radiation reaction interaction

868

00:41:27,340 --> 00:41:25,070

presumably which involves a wheeler

869

00:41:29,770 --> 00:41:27,350

Fineman advance for target interaction

870

00:41:32,710 --> 00:41:29,780

yes that is the obvious question to ask

871

00:41:35,290 --> 00:41:32,720

if you say that one way of answering it

872

00:41:37,180 --> 00:41:35,300

which there is another way of getting it

873

00:41:40,570 --> 00:41:37,190

instantaneously and I should tell you to

874

00:41:43,300 --> 00:41:40,580

be full disclosure nets to use the

875

00:41:45,220 --> 00:41:43,310

constraint equations which are elliptic

