WEBVTT

1
00:00:02.490 --> 00:00:08.910
Sarah Jeffreson: Okay wonderful well today we have the pleasure of having can bend Tilbury Ken is a professor at nyu.

2
00:00:08.910 --> 00:00:10.469
Sarah Jeffreson: And also.

3
00:00:10.830 --> 00:00:13.469
Sarah Jeffreson: sort of research scientist at that distance yeah.

4
00:00:14.700 --> 00:00:15.210
Sarah Jeffreson: and

5
00:00:16.410 --> 00:00:20.580
Sarah Jeffreson: You know I like a defining aspect of career, I think has been.

6
00:00:20.820 --> 00:00:31.920
Sarah Jeffreson: Looking first kind of the the traces maybe of all of the physics that sort of hiding potentially beyond the standard model in that sort of astrophysical.

7
00:00:33.360 --> 00:00:39.540
Sarah Jeffreson: universe, as we see it, so Ken thanks so much for for joining us.

8
00:00:41.040 --> 00:00:46.440
Ken Van Tilburg: Thank you for that introduction I think that's exactly right so.

9
00:00:47.460 --> 00:00:52.320
Ken Van Tilburg: yeah i'm trained as a particle physicist, but I try to use.

10
00:00:53.850 --> 00:01:13.380
Ken Van Tilburg: unusual systems, usually involving precision instruments or just precision observable to look for new new types of physics beyond the standard model so both in the laboratory and and astrophysical and cosmological settings so today I will tell you about an idea.

11
00:01:15.090 --> 00:01:18.240

Ken Van Tilburg: To look for weekly coupled particles.

12
00:01:18.690 --> 00:01:19.830
Ken Van Tilburg: Around stars.

13
00:01:20.520 --> 00:01:22.230
Sarah Jeffreson: So, again.

14
00:01:22.350 --> 00:01:23.520
Sarah Jeffreson: Because we're having a little.

15
00:01:23.520 --> 00:01:25.560
Sarah Jeffreson: bit sound trouble on our.

16
00:01:29.100 --> 00:01:29.670
Sarah Jeffreson: Try.

17
00:01:31.020 --> 00:01:31.890
Sarah Jeffreson: To the other.

18
00:01:38.610 --> 00:01:38.940
Sarah Jeffreson: PC.

19
00:01:50.550 --> 00:01:52.620
Ken Van Tilburg: it's possible it's the nyu network.

20
00:01:54.420 --> 00:01:56.280
Sarah Jeffreson: I think it's element work like.

21
00:01:56.910 --> 00:02:00.270
Ken Van Tilburg: This issue, some other things as well, fortunately.

22
00:02:00.720 --> 00:02:02.460
Sarah Jeffreson: Okay, I.

23
00:02:03.450 --> 00:02:03.990
Sarah Jeffreson: That ship.

24
00:02:07.980 --> 00:02:08.220
Ken Van Tilburg: So.

25
00:02:08.550 --> 00:02:11.130
Sarah Jeffreson: let's go ahead now sorry about that.

26
00:02:11.760 --> 00:02:12.240
Sarah Jeffreson: I see.

27
00:02:12.330 --> 00:02:14.670
Ken Van Tilburg: yeah I think the zoom folks.

28
00:02:14.730 --> 00:02:16.290
Sarah Jeffreson: are saying it's fine.

29
00:02:29.280 --> 00:02:30.480
Ken Van Tilburg: hi Peter wait for a little bit.

30
00:02:38.160 --> 00:02:38.700
Sarah Jeffreson: Go ahead.

31
00:02:40.380 --> 00:02:54.810
Ken Van Tilburg: Thank you okay yeah no worries so right, so this is the thing I will talk about today is an idea I had in June of 2020 so mid pandemic hallucination but that.

32
00:02:54.840 --> 00:02:55.830
Ken Van Tilburg: Now is shaping.

33
00:02:56.280 --> 00:02:57.390
Ken Van Tilburg: At least part of my research.

34
00:02:57.390 --> 00:02:59.970
Ken Van Tilburg: program and the idea is to look.

35
00:02:59.970 --> 00:03:17.640
Ken Van Tilburg: For new weekly couple of particles beyond the standard model around stars so just as a you know one one slide summary here on the right i'm showing a little animation of it, the simulation simulation is there still ongoing.

36
00:03:18.270 --> 00:03:18.600
Ken Van Tilburg: Of.

37

00:03:19.200 --> 00:03:22.230
Ken Van Tilburg: The solar system, so you see the star in the middle of the sun.

38
00:03:24.030 --> 00:03:33.030
Ken Van Tilburg: And then Venus earth MARS and on the outskirts here is Jupiter so it's a top down view of the of the solar system in units of a you.

39
00:03:34.140 --> 00:03:43.260
Ken Van Tilburg: And the the colored orbits are particles that were initially emitted by the sun onto bound orbits and.

40
00:03:44.220 --> 00:03:57.960
Ken Van Tilburg: The key idea is that these orbits going to accumulate over time so as as the sun is emitting these particles, some of them are most of them, in fact, will fly out to infinity typically they're admitted.

41
00:03:58.980 --> 00:04:01.170
Ken Van Tilburg: On relativistic orbits that are unbound.

42
00:04:03.120 --> 00:04:15.870
Ken Van Tilburg: But some are limited in the band orbits and they will accumulate over time, but then she over the age of the sun or the Star and question and that can lead to new prospects for.

43
00:04:15.900 --> 00:04:16.710
Ken Van Tilburg: For detection.

44
00:04:16.830 --> 00:04:25.290
Ken Van Tilburg: So, as you can see some some of these orbits are crossing earth, so we can try to look look for these particles with experiments on earth.

45
00:04:26.760 --> 00:04:30.990
Ken Van Tilburg: We can look for other signatures, like their decays.

46
00:04:33.270 --> 00:04:48.960
Ken Van Tilburg: yeah and anomalous schooling signatures as well, so so that's that's the the basic idea and it's So the first two papers I listed here, the second one with Robert leaves and he was a postdoc at Stanford.

47

00:04:51.600 --> 00:04:55.680
Sarah Jeffreson: You again yeah minutes of the speaker to a different computer.

48
00:04:56.700 --> 00:05:00.690
Sarah Jeffreson: Okay, because it's fine on some people's computers, but it's back to you.

49
00:05:39.300 --> 00:05:39.930
Morgan Elowe MacLeod: Can you hear us now.

50
00:05:41.070 --> 00:05:41.400
Ken Van Tilburg: yeah.

51
00:05:42.600 --> 00:05:43.710
Ken Van Tilburg: how's the audio in the room now.

52
00:05:44.190 --> 00:05:47.760
Morgan Elowe MacLeod: We it seems good so good sorry about that.

53
00:05:48.300 --> 00:05:49.350
Ken Van Tilburg: yeah no worries.

54
00:05:50.640 --> 00:06:08.910
Ken Van Tilburg: Like the LIFE now so yeah the the the papers i've listed here so some of them are with Robert leave them be including ongoing work with courage mobility about simulations preliminary, one of which i'm showing here of this solar basin.

55
00:06:10.230 --> 00:06:18.060
Ken Van Tilburg: And then we're also looking for for these particles indirectly by by their decays near the sun.

56
00:06:18.720 --> 00:06:35.340
Ken Van Tilburg: With X X Ray observatories This is with boulder Rocco who's now at Santa Cruz shama Waxman is a student at nyu and Brian Griffin said a was a new star so an x Ray experimentalists an observer engine We wanted a perimeter Institute.

57
00:06:37.500 --> 00:06:44.400
Ken Van Tilburg: yeah so so this population of and particles I call a stellar basin or solar based in Toronto sun.

58

00:06:45.720 --> 00:06:56.790
Ken Van Tilburg: So okay it's just the, since this is maybe not that familiar to the to the audience, just a quick recap of stellar admission so.

59
00:06:58.650 --> 00:07:05.370
Ken Van Tilburg: The sun in any most stars in fact they're kind of poor photon amateurs, which is why they they live so long.

60
00:07:06.030 --> 00:07:18.810
Ken Van Tilburg: For two reasons, so the first reason is that the surface is quite cool so for the sun at 6000 kelvin, whereas the the core is a much hotter right, but the but the photons from the core don't.

61
00:07:20.250 --> 00:07:26.160
Ken Van Tilburg: escape, at least not initially that they get reabsorbed in the core and get radiation pressure.

62
00:07:28.290 --> 00:07:28.860
Ken Van Tilburg: The.

63
00:07:30.090 --> 00:07:44.820
Ken Van Tilburg: yeah, and so the second reason is that it was when I mentioned that the mean free path is is very short so there's only affected admission from a small layer at the surface, which is further more cool.

64
00:07:46.020 --> 00:07:48.330
Ken Van Tilburg: And that actually leads to some.

65
00:07:50.820 --> 00:07:54.060
Ken Van Tilburg: interesting fact so, for example, that neutrino cooling.

66
00:07:55.410 --> 00:07:59.760
Ken Van Tilburg: may or may not be negligible for some stars, it is negligible for for the sun.

67
00:08:00.870 --> 00:08:16.290
Ken Van Tilburg: But it is not so for other stars, like, for example, neutron stars, so a hot neutron star or a young new dress or in the first hundred thousand years of its life tools, primarily through neutrino emission not through surface submission from from photons.

68
00:08:17.550 --> 00:08:19.890

Ken Van Tilburg: And this is despite the fact that the effective coupling.

69
00:08:20.400 --> 00:08:27.840
Ken Van Tilburg: Of neutrinos is something like 2020 or more orders of magnitude smaller than that of a photon.

70
00:08:29.550 --> 00:08:29.970
Ken Van Tilburg: Okay.

71
00:08:31.170 --> 00:08:37.650
Ken Van Tilburg: And so, this also applies to a hypothetical new particles here i'm calling it an axiom.

72
00:08:38.880 --> 00:08:47.040
Ken Van Tilburg: But it can be really any type of weekly couple particle that can escape, just like a neutrino So this was realized in the late 70s, that that.

73
00:08:48.090 --> 00:09:03.390
Ken Van Tilburg: Just by not observing anomalous schooling of stars and that are stellar codes work pretty well, that you can constrain the couplings of new particles like axioms and so, most of it has focused on on relativistic emission of these particles.

74
00:09:05.190 --> 00:09:14.460
Ken Van Tilburg: And some experiments have been devised to also look for them on earth right, so if if these particles are emitted by the sun, we can try to look for them.

75
00:09:15.480 --> 00:09:19.230
Ken Van Tilburg: In with the directors honors for these unbound particles.

76
00:09:21.180 --> 00:09:34.860
Ken Van Tilburg: The same detectors typically can also look for these particles if they're dark matter, as I said, there i'm assuming that these particles are going to be weekly coupled so they could potentially play the role of dark matter as well.

77
00:09:36.300 --> 00:09:46.200
Ken Van Tilburg: And so yeah often the same detectors can look for both the solar emitted particles, as well as the dark dark matter of population if if they if it exists.

78
00:09:49.140 --> 00:09:51.360
Ken Van Tilburg: What I pointed out, was that there is something.

79
00:09:52.410 --> 00:09:56.520
Ken Van Tilburg: peculiar about most of these particles.

80
00:09:57.180 --> 00:10:06.330
Ken Van Tilburg: Emission so we don't normally don't think about it, but but photons are masters right, so they they necessarily escaped to infinity they don't have bound orbits, but these new particles.

81
00:10:06.630 --> 00:10:25.080
Ken Van Tilburg: Have a mess, so a small fraction of them can be emitted on to bound orbits and accumulate over time and it's a small fraction but the long accumulation time means that there's significant consequences for for lifetime, so it looks like it's a non relativistic particle around the sun.

82
00:10:27.000 --> 00:10:32.460
Ken Van Tilburg: So it kind of looks like dark matter, except it's not causing logic, we produce its solar produced.

83
00:10:34.050 --> 00:10:35.010
Ken Van Tilburg: So yeah.

84
00:10:36.090 --> 00:10:43.500
Ken Van Tilburg: This is the all of the particle physics, you need to know, basically, if you have a light bulb sonic particle.

85
00:10:45.000 --> 00:10:52.350
Ken Van Tilburg: there's only a finite number of possibilities depending on it's quantum numbers, so if it's a scale or particle.

86
00:10:52.680 --> 00:11:00.780
Ken Van Tilburg: So it's a parody even spend zero article pseudo scale if it's a parody odd spin zero particle or it could be a spin one particle a vector.

87
00:11:01.680 --> 00:11:13.170
Ken Van Tilburg: there's really only 10 cufflinks so if it's if it's a scale or a couple two electrons quarks photons and blue ones, and so, these are the four leading interactions you can you can possibly have.

88

00:11:13.830 --> 00:11:22.110
Ken Van Tilburg: classify all of them same with the pseudo scale or again electron sparks photons and glue ons and a vector at only has two possibilities.

89
00:11:22.650 --> 00:11:33.600
Ken Van Tilburg: One thing that we call it genetically mixed photon so it sort of has some mixed propagation with a regular photon with parameters to buy some small coupling epsilon.

90
00:11:34.830 --> 00:11:35.760
Ken Van Tilburg: Or it can couple to.

91
00:11:36.930 --> 00:11:44.220
Ken Van Tilburg: It can couple like a regular photon very except the charges are not electric charge but very on number minus leptons number.

92
00:11:45.000 --> 00:11:55.020
Ken Van Tilburg: So so for the beginning of the doctor i'm going to focus on just this pseudo scale of coupling two electrons So what can happen is just brehm strong off often electron so.

93
00:11:55.440 --> 00:12:04.950
Ken Van Tilburg: let's say time goes from left to right so an electron scatters off an eye on and the sun, and in that electron Ion scattering process.

94
00:12:05.850 --> 00:12:18.150
Ken Van Tilburg: there's some brim struggling radiation, except it's not a not a photon this time but it's an axiom and likewise an analog of the conference gathering process where you produce this accion particle through this coupling.

95
00:12:20.220 --> 00:12:22.710
Ken Van Tilburg: If if, for example, you have a photon coupling.

96
00:12:23.970 --> 00:12:40.560
Ken Van Tilburg: You know, you can have photons scattering off of ions and producing the sexy, and that can also lead to the case of these axioms if you just have the electron coupling the gays are typically pretty slow, because they have to go through a loop it's not so important.

97
00:12:41.670 --> 00:12:48.510

Ken Van Tilburg: And sort of this, the second part of the talk going to discuss this vector particle and alone.

98
00:12:49.800 --> 00:12:53.100
Ken Van Tilburg: Okay, so, but this is this.

99
00:12:54.300 --> 00:13:12.690
Ken Van Tilburg: The first for the axiom particle so you don't really need to know all of the particle physics, but i'm just going to show you here the the effective coupling as a function of massive this particle so this parameter by this G coupling and basically if the coupling is.

100
00:13:13.740 --> 00:13:22.440
Ken Van Tilburg: If the dimension was coupling is larger than three times N minus 13 or so, and if the particle sufficiently light so below the.

101
00:13:24.240 --> 00:13:31.080
Ken Van Tilburg: The temperature of the star like a which is 1010 kV for red giant and one kV for typical white dwarf.

102
00:13:31.680 --> 00:13:46.170
Ken Van Tilburg: Then you would anomalously cool so anywhere in this Gray region, you would anomalously cool red giant stars and shorten their lifetime increase the the the mass of the poor at the at the end of its life.

103
00:13:48.120 --> 00:13:57.420
Ken Van Tilburg: yep and on the right here i'm showing the spectrum of emitted axiom particles for the two different.

104
00:13:58.800 --> 00:14:02.760
Ken Van Tilburg: coupling so the orange bird would be what what what the spectrum looks like.

105
00:14:03.900 --> 00:14:04.650
Ken Van Tilburg: If this.

106
00:14:06.060 --> 00:14:12.840
Ken Van Tilburg: particle can be can be emitted by the sun with this coupling 10th or minus 13 that's a still allowed.

107
00:14:14.250 --> 00:14:32.190
Ken Van Tilburg: So it's below this this great curve and yeah so so just as a point it's emitted from the core of the sun and that's why the

typical energy is of order one kV which corresponds to the thermal energy at 50 million kelvin the Court solar core temperature.

108
00:14:33.870 --> 00:14:39.330
Ken Van Tilburg: So this this spectrum would be the spectrum of a mass loss accion.

109
00:14:40.500 --> 00:14:52.200
Ken Van Tilburg: And here i'm showing a cartoon so here i'm also showing this differential energy loss rate per unit volume per unit, energy, so you can think of it as a spectrum.

110
00:14:53.190 --> 00:15:06.570
Ken Van Tilburg: Now, on a log scale and so at at low energies, so if you're looking at the Masters case low energy is your face space suppressed so typically scales, like some polynomial as a function of frequency.

111
00:15:07.350 --> 00:15:20.040
Ken Van Tilburg: And then, once as a function of energy and for energies far above the temperature eventually you get the boltzmann's depression, because there's not enough energy in the Court to produce very high energy modes.

112
00:15:22.350 --> 00:15:32.070
Ken Van Tilburg: But now, if if these particles have a mass let's say not too far removed from the temperature of the star, then the spectrum it gets modified and.

113
00:15:32.700 --> 00:15:48.420
Ken Van Tilburg: It looks like the black curve over here, and then the new possibility that opens up is that in this blue sliver you have just enough energy to produce the particle but not enough to escape the potential of the solar system so.

114
00:15:50.940 --> 00:15:59.730
Ken Van Tilburg: And those were those particles would be emitted onto a bound orbit and in fact that's you can estimate by dimensional analysis.

115
00:16:01.560 --> 00:16:12.630
Ken Van Tilburg: The fraction of the blue sliver compared to everything else and it's basically because you're sort of you can emit into all parts of face base and the the total integral under the curve here.

116
00:16:13.020 --> 00:16:28.110

Ken Van Tilburg: Typically, gives you something like that scales like temperature to the fourth power, whereas if you're only integrating over the blue sliver you get something like the ball and face space where you can emit which goes like the escape velocity cubed.

117
00:16:29.160 --> 00:16:37.110
Ken Van Tilburg: And the mass of the fourth, so the ratio is typically of order the fractional ratio so sorry that's.

118
00:16:38.370 --> 00:16:47.130
Ken Van Tilburg: redundant, the ratio of bound to unbound orbits if the mass is close to the temperature goes like the escape cute so escape velocity jude.

119
00:16:47.910 --> 00:17:02.730
Ken Van Tilburg: units of the speed of light where the speed of light is one so for the sun in the core of the sun, the escape velocity is a little bit higher than 10 to the minus three so one part in a billion of these axioms would be admitted into bound orbit which sounds small.

120
00:17:03.840 --> 00:17:09.300
Ken Van Tilburg: But let me give you a counter argument for why it's not small okay so.

121
00:17:11.370 --> 00:17:31.980
Ken Van Tilburg: I gave you the heuristic argument, but the the actual formula that I derived in my paper from June 2020 is this one, so if you ask what is the energy density injection rate inbound orbits as observed from a radius are outside of the star.

122
00:17:33.030 --> 00:17:40.950
Ken Van Tilburg: At some volume integral of some function this cute delta, which is not so important that the most important things that it falls off as one over to the fourth.

123
00:17:42.390 --> 00:17:46.770
Ken Van Tilburg: Whereas the inbound emissions, so the stuff that gets submitted.

124
00:17:48.000 --> 00:18:01.230
Ken Van Tilburg: to infinity right just by ghosts is law goes like one over R squared so this integral here would be the luminosity and then the energy density would be just be that diluted by one over for pi R squared by gases.

125

00:18:02.340 --> 00:18:18.000
Ken Van Tilburg: So this is an energy density injection rate, and this is just the instantaneous density from inbound orbits So if you ask what's what's the ratio after of these two after some accumulation time TAO if these bound orbits accumulate for some time out sometime TAO.

126
00:18:19.470 --> 00:18:20.220
Ken Van Tilburg: You find.

127
00:18:22.230 --> 00:18:23.730
Ken Van Tilburg: You find this so.

128
00:18:25.890 --> 00:18:28.860
Ken Van Tilburg: yeah if you complete these integrals again it's not so important what they are.

129
00:18:30.060 --> 00:18:39.150
Ken Van Tilburg: The The end result is that it's a product this ratio is a product of a very big number and a very small number so as promised before.

130
00:18:39.510 --> 00:18:52.770
Ken Van Tilburg: You get something of order via escape tube turns out it's like the escape squared at the radius R times V escaped in the core of the star, which is, which was this thing I derived heuristic Lee and this is small.

131
00:18:55.380 --> 00:18:56.970
Ken Van Tilburg: let's say at earth's location.

132
00:18:58.200 --> 00:19:08.610
Ken Van Tilburg: But this factor is enormous right so tau could potentially be as long as the age of the sun so 4.6 billion years and our for.

133
00:19:09.030 --> 00:19:32.370
Ken Van Tilburg: Our location is eight light minutes right, so this small factors counteracted by 4 billion years over eight minutes and, indeed, so if let's dramatize it as a function of towel so tau is a million years, then these ratio this tiny sliver as it accumulates eventually gives you something.

134
00:19:33.810 --> 00:19:37.200
Ken Van Tilburg: yeah so the boundary mission starts dominating after a million years.

135
00:19:38.340 --> 00:20:00.420
Ken Van Tilburg: So what this accumulation, time is is was not known when I wrote my first paper, and so I made some crude estimates had some conservative estimate based on just the chaotic timescale of orbits in the solar system that has 10 million years if you look at some asteroid data.

136
00:20:01.830 --> 00:20:11.760
Ken Van Tilburg: And some forward propagation of what they do you get a fiduciary time of entity eight years the asteroid orbits are sort of a.

137
00:20:13.320 --> 00:20:33.090
Ken Van Tilburg: are biased and not not representative of the orbits that that are emitted from the sun, and so, if you if you do some other estimates based on just rates of close encounters and secular perturbation theory the typical time you get is is basically the age of the solar system so.

138
00:20:34.980 --> 00:20:35.250
yeah.

139
00:20:36.960 --> 00:20:37.800
Ken Van Tilburg: This is.

140
00:20:39.030 --> 00:20:46.230
Ken Van Tilburg: These are all the technicalities for the Doc the rest will be sort of pictures and we can discuss, so the point is.

141
00:20:47.100 --> 00:21:00.840
Ken Van Tilburg: particles are emitted into bound orbits they accumulate and they can be important that, after a long accumulation time for for detection and from here on out i'm going to.

142
00:21:01.470 --> 00:21:21.570
Ken Van Tilburg: discuss how this basin evolves so i'm going to try to figure out what this accumulation, time is for the sun and i'll show you preliminary results on analyses based on on this population of particles, I am happy to take a question now if you have any national stuffing.

143
00:21:25.830 --> 00:21:26.100
Ken Van Tilburg: We.

144
00:21:27.780 --> 00:21:28.350

Sarah Jeffreson: Have a question.

145
00:21:30.510 --> 00:21:31.470
Sarah Jeffreson: about this.

146
00:21:31.560 --> 00:21:32.070
town.

147
00:21:33.390 --> 00:21:34.410
Sarah Jeffreson: More about.

148
00:21:36.030 --> 00:21:36.360
Morgan Elowe MacLeod: You go.

149
00:21:39.060 --> 00:21:39.360
Sarah Jeffreson: yeah.

150
00:21:47.970 --> 00:21:48.510
Morgan Elowe MacLeod: yeah.

151
00:21:52.260 --> 00:21:52.770
Sarah Jeffreson: So.

152
00:22:02.280 --> 00:22:04.110
Ken Van Tilburg: i'm having a really hard time hearing you.

153
00:22:07.350 --> 00:22:07.560
Morgan Elowe MacLeod: know.

154
00:22:10.620 --> 00:22:14.790
Ken Van Tilburg: Why, it is the layup enough time you asking why why that why I put it there.

155
00:22:15.060 --> 00:22:15.390
yeah.

156
00:22:17.850 --> 00:22:20.520
Ken Van Tilburg: Well, that was sort of a conservative estimate so.

157
00:22:21.390 --> 00:22:32.400

Ken Van Tilburg: it's a huge underestimate so So in fact well spoiler alert, I think the effective TAO for orbits crossing earth's orbit is.

158
00:22:34.140 --> 00:22:41.940
Ken Van Tilburg: Is a 1.2 billion years so it's somewhere in between this asteroid estimate and this optimistic estimate based on.

159
00:22:42.210 --> 00:22:43.830
Ken Van Tilburg: secular perturbation theory.

160
00:22:44.340 --> 00:22:53.340
Ken Van Tilburg: I just basically Italy up enough time the the face face gets scrambled at least partially, and so, so that so that timescale.

161
00:22:53.760 --> 00:23:04.680
Ken Van Tilburg: was just a conservative lower bound on how short this accumulation time was but but already, then you know even with this super conservative estimate, it was already interesting like the bound.

162
00:23:05.880 --> 00:23:13.230
Ken Van Tilburg: The bound fraction would be larger than the that the bone density would be larger than the unbound density locally.

163
00:23:14.100 --> 00:23:16.380
Sarah Jeffreson: gotcha gotcha so you care about the APP and, of course, the.

164
00:23:16.380 --> 00:23:19.830
Sarah Jeffreson: orbits gets crumbled but they don't particles and get rejected.

165
00:23:20.580 --> 00:23:24.810
Ken Van Tilburg: So they do, they do and that's that's what i'll talk about now yeah.

166
00:23:28.470 --> 00:23:31.770
Ken Van Tilburg: So it was it was actually not known.

167
00:23:33.150 --> 00:23:36.570
Ken Van Tilburg: Just the simple question what's the gravitational lifetime so.

168
00:23:36.600 --> 00:23:38.940

Ken Van Tilburg: By gravitational I mean the lifetime against.

169
00:23:40.410 --> 00:23:42.060
Ken Van Tilburg: emotional resonances.

170
00:23:42.060 --> 00:23:52.770
Ken Van Tilburg: And kicks and he kicks from close encounters of just a non interacting particle in the solar system so stability of the solar system was studied.

171
00:23:53.730 --> 00:24:14.670
Ken Van Tilburg: You know by by they learn a Western gas the classical mechanics giants from back in the day, but they mostly focused on to orbit circular orbit in a plane right interactions of the planets obviously not for sort of generic parts of face space.

172
00:24:17.160 --> 00:24:28.380
Ken Van Tilburg: And so yeah some simulations had been done on dark matter capture in the solar system and dark matter capture is the time to reverse problem of each section right so.

173
00:24:30.390 --> 00:24:39.540
Ken Van Tilburg: gravity is time reversal invariant So if you get the capture rate, you can also get the rejection rate, but again, it was not exactly the precise question that we wanted to ask.

174
00:24:41.370 --> 00:24:51.450
Ken Van Tilburg: So that's why we're doing in body simulations with Robert ladies and being carried, you have an ad or finding some pretty cool results i'll show you some of them here.

175
00:24:52.410 --> 00:25:02.610
Ken Van Tilburg: So this is important not just to get the final value of town, but also to see what the annual modulation is of the density locally so Earth is moving in an eccentric orbit.

176
00:25:03.540 --> 00:25:20.610
Ken Van Tilburg: So, as it gets closer you might think you have more density versus when it's at helium where you get less than city, they might even be some sort of astrology correlation where the location of the planets may matter by in particular jupiter's location may matter.

177
00:25:23.490 --> 00:25:29.220
Ken Van Tilburg: For the density, because, as it can shape this sort of this this basin density.

178
00:25:30.570 --> 00:25:42.900
Ken Van Tilburg: Its orbits is a symmetric a eccentric so i'm going to show you a animation now, so this is a very fast on human timescales so i'm not showing the particle orbiting now.

179
00:25:43.320 --> 00:25:49.200
Ken Van Tilburg: Now i'm just going i'm showing you the evolution of the capillary in orbit as a function of time.

180
00:25:50.070 --> 00:26:07.140
Ken Van Tilburg: So on the top is a side view on the right as a side view, this is a top view of the solar system, so, if I can just go back from the beginning, this is it's admitted on a from the sun right, so these particles are emitted on to very radial orbits.

181
00:26:09.390 --> 00:26:28.230
Ken Van Tilburg: And i'm just showing 10 here, and because the the solar system, so if there is no planets the solar system these orbits would just stay fixed and remain on keep layering orbits but deleting order the solar system breaks angular momentum conservation in the.

182
00:26:29.670 --> 00:26:46.440
Ken Van Tilburg: In the X and y directions so you'll see that in these side views the the orbits become circular at least the projection onto the side of US become circular pretty quickly so that's the scrambling time in about a million years or 10 million years, whereas.

183
00:26:47.700 --> 00:26:51.840
Ken Van Tilburg: From the top view the angular momentum the Z direction does not get scrambled as quickly.

184
00:26:53.520 --> 00:27:05.790
Ken Van Tilburg: So here yeah so that the angular momentum the directions days, more or less constant but it gets pretty scrambled pretty quickly and there's some interesting behavior like light Of course I oscillations etc.

185
00:27:07.770 --> 00:27:09.870
Ken Van Tilburg: In the orbits here so.

186
00:27:11.340 --> 00:27:24.990
Ken Van Tilburg: Right and but you see at least you know over these 5 million years of this little animation that that none of the particles

get rejected so they are semi major access or their binding energy stays approximately fixed.

187
00:27:28.020 --> 00:27:39.120
Ken Van Tilburg: So we've simulated thousands of particles, so this is now the semi major access as a function of time from the birth of the solar system to 100 million years.

188
00:27:40.290 --> 00:27:45.450
Ken Van Tilburg: Let me just clean it up a little bit and show you fewer of them so most of the particles are emitted.

189
00:27:46.650 --> 00:28:02.730
Ken Van Tilburg: close to the sun just from face face reasons and the ones that don't cross Venus and earth and are extremely stable right, so this any major axis is basically constant as a function of time these orbits don't cross Earth.

190
00:28:03.780 --> 00:28:16.500
Ken Van Tilburg: But as you go further and further out, you can have close encounters with Venus and earth and if you're very far out so if basically if the orbited if you're sending major access is above 2.6 say you.

191
00:28:17.400 --> 00:28:36.330
Ken Van Tilburg: Jupiter can slingshot you out and typically does so within 10 million years, so this particle gets ejected quickly any particle so here like a lot of these particles once they once they reach 2.5 2.6 a year, they just get kicked out so all the vertical lines going up here are injections.

192
00:28:37.710 --> 00:28:44.820
Ken Van Tilburg: That happens pretty fast So these are all of the rejected particles and preliminary run that we did.

193
00:28:46.230 --> 00:28:54.990
Ken Van Tilburg: So, none of the none of the particles close to earth were rejected, only did the faraway ones.

194
00:28:56.640 --> 00:29:07.380
Ken Van Tilburg: And yeah Robert laser beam I collaborated can come up with some cool tricks, so that the first sort of a done brute force way to simulate what happens is to.

195
00:29:07.800 --> 00:29:18.300

Ken Van Tilburg: continuously inject particles over the age of the sun integrate forward and check how much how many crossings, there are with earth to get a discrete estimator for the density.

196
00:29:20.250 --> 00:29:28.590
Ken Van Tilburg: And there we put a lower bound of 1.1 billion years it's still somewhat biased, because not all of the simulations that finished running.

197
00:29:29.820 --> 00:29:32.220
Ken Van Tilburg: that's why it's a lower bound and not an estimate.

198
00:29:33.330 --> 00:29:36.510
Ken Van Tilburg: And here i'm showing the velocity face space so.

199
00:29:37.590 --> 00:29:59.130
Ken Van Tilburg: incentive coordinate so Earth is in on a circular orbit with some as the neutral velocity normalize the one, and so this semi circle anything in the semi circle would be a bound orbit and you see, most of the orbits are quite eccentric so they're not on circular orbits.

200
00:30:00.300 --> 00:30:16.980
Ken Van Tilburg: they're mostly they're mostly radial ish, and yet they get scrambled in this way and not all of faith based is occupied so so very retro grade circular orbits are have not yet been populated are typically do not get populated.

201
00:30:19.500 --> 00:30:28.740
Ken Van Tilburg: But Robert strict was was actually was to integrate backwards, so he did the time to reverse problem instead of emitting from the sun and then checking.

202
00:30:29.160 --> 00:30:45.240
Ken Van Tilburg: How many times you've crossed Earth is the opposite thing he emitted from earth these particles backwards in time and checked, how many times of particles across the sun which happens much more often and as a more efficient way of estimating the density.

203
00:30:46.890 --> 00:30:56.550
Ken Van Tilburg: And you can estimate how it's going to be in our paper with this formula and we get a much more precise estimate of 1.4 billion years So these are doing the Ben and checks.

204
00:31:01.650 --> 00:31:03.900
Ken Van Tilburg: yeah of this lifetime we.

205
00:31:04.950 --> 00:31:06.930
Ken Van Tilburg: And in fact sorry, this is an old.

206
00:31:10.260 --> 00:31:17.070
Ken Van Tilburg: we've corrected for some bar I season and 2 billion years is our is our going to be in on number, I believe.

207
00:31:18.510 --> 00:31:29.190
Ken Van Tilburg: yeah with similar results for how the faith based instead he gets scrambled although it's fewer statistics, because we have just we're emitting from from earth so there's a few statistics for this.

208
00:31:30.000 --> 00:31:38.970
Ken Van Tilburg: And we've checked that it doesn't depend on the algorithm used so we use a is 15 which has some 15th order integrator as well as some 12 sorter algorithm.

209
00:31:40.080 --> 00:31:44.130
Ken Van Tilburg: So yeah so the forward and backwards and then degree as well.

210
00:31:46.560 --> 00:31:53.160
Ken Van Tilburg: And this is just showing you the different simulation so all of the forward simulations which have some survival bias.

211
00:31:55.230 --> 00:32:07.620
Ken Van Tilburg: We had 256 backwards simulations that all finished, so we rent run them backwards in time to 4.6 billion years in the past or until the particle is rejected.

212
00:32:08.520 --> 00:32:21.960
Ken Van Tilburg: Going back in time so that these these first 256 particle dust particles we injected all of all of those simulations that finished in that sense, so that's an unbiased sample and that was the.

213
00:32:22.680 --> 00:32:30.960
Ken Van Tilburg: You know that was the number I quoted here 1.4 billion years is that the peak of this distribution but we've started thousands and, if you take the first.

214
00:32:32.310 --> 00:32:33.720
Ken Van Tilburg: Most of which I finished.

215
00:32:34.980 --> 00:32:38.970
Ken Van Tilburg: But not all we get a slightly lower estimate so, so this is.

216
00:32:40.770 --> 00:32:56.250
Ken Van Tilburg: biased low so so you can take this estimate of 1.2 as a conservative estimate, but the real answer is likely in between here and the spread is just a bootstrap the way of getting our uncertainty, so we don't know it perfectly even just from limited statistics.

217
00:32:59.940 --> 00:33:09.360
Ken Van Tilburg: yeah so i'm going to skip this, so this is what you get in the end for the final density so we've computed this.

218
00:33:10.590 --> 00:33:27.990
Ken Van Tilburg: These plots for exactly from our simulations so no no heuristics so what i'm showing you here is the final density at earth location as a function of particle as a function of this accion mass for different couplings and you get some interesting.

219
00:33:29.040 --> 00:33:33.090
Ken Van Tilburg: dynamics so as you increase the coupling you get more and more and more.

220
00:33:34.380 --> 00:33:51.240
Ken Van Tilburg: If the coupling is as largest 10 to the minus 11 you get as much density I forgot the units i'm sorry this, these are units of gv per centimeter cube so that for reference the Gray line is the local dark matter density.

221
00:33:52.290 --> 00:33:58.020
Ken Van Tilburg: So you can exceed the local dark matter and see if the coupling is very big and there's i'm.

222
00:33:59.160 --> 00:34:08.640
Ken Van Tilburg: curious curious physics so as you increase the coupling eventually you saturate too detailed balance so it's basically where this basin of particles.

223
00:34:09.690 --> 00:34:23.850
Ken Van Tilburg: has an equal admission rate and absorption rate than the sun, so you achieve a detailed balance with your occupation number, this is that face base occupation number gets that have a bose-einstein occupation number.

224
00:34:24.900 --> 00:34:26.760
Ken Van Tilburg: So Eric will have rates with us on basically.

225
00:34:28.620 --> 00:34:33.810
Ken Van Tilburg: um so yeah so you have quite a high density around the star.

226
00:34:35.550 --> 00:34:43.950
Ken Van Tilburg: So you can look for this with experiments on earth right So you see of this density of particles, you can you can look for them.

227
00:34:45.330 --> 00:34:46.980
Ken Van Tilburg: With dark matter experiments.

228
00:34:48.180 --> 00:34:54.210
Ken Van Tilburg: Even though this particle again is not dark matter it's produced by the sun, but it kind of looks and smells like dark matter.

229
00:34:54.720 --> 00:35:04.950
Ken Van Tilburg: And indeed dark matter detectors can look for it so i'm not going to go into all of the details on dark matter detectors but the basic idea is that a particle can be.

230
00:35:06.180 --> 00:35:12.720
Ken Van Tilburg: This axiom particle a couple of electrons so it can eyes xenon Adam as it gets absorbed.

231
00:35:14.070 --> 00:35:24.960
Ken Van Tilburg: And that ionization event will cause some simulation light which is called s one, but the Ionized electrons can also drift.

232
00:35:26.040 --> 00:35:34.020
Ken Van Tilburg: upwards and produce some additional signal called as to from from this drift and you can use these two things to.

233
00:35:37.110 --> 00:35:44.190
Ken Van Tilburg: discriminate against the background and get an energy estimate for what the mass of the party or the energy of the particle was.

234
00:35:46.260 --> 00:35:49.740
Ken Van Tilburg: yeah and get some localization information as well, so.

235
00:35:50.820 --> 00:36:02.100
Ken Van Tilburg: This is a picture from the xenon want an experiment which publish their results in June 2020 so I, so I scrambled to finish up my to finish up this this idea.

236
00:36:02.490 --> 00:36:11.730
Ken Van Tilburg: Because indeed they what they found was an excess of events at low energies with a typical energy of order the.

237
00:36:12.300 --> 00:36:30.210
Ken Van Tilburg: Core temperature son I don't I I think this access is not quite really may be some radioactive it likely is some radioactive contamination, but anyway it's a they could have possibly seen something as i'll show next.

238
00:36:32.880 --> 00:36:33.480
Ken Van Tilburg: So.

239
00:36:34.740 --> 00:36:37.860
Ken Van Tilburg: What they interpreted it, as was a.

240
00:36:39.150 --> 00:36:45.930
Ken Van Tilburg: let's look in this block a solar accion So if you say that it's a relativistic solar accion so nationalists accion.

241
00:36:47.070 --> 00:36:50.430
Ken Van Tilburg: You can get this you can fit this excess with.

242
00:36:51.690 --> 00:37:02.700
Ken Van Tilburg: With such a population, the problem was that in there parameter space, so if you can couple two electrons here, you can couple two photons and you can coupled the nuclei.

243
00:37:03.180 --> 00:37:16.020
Ken Van Tilburg: And anywhere in the blue band you you fit well this excess of events, except the problem was that the only allowed parameter space was this orange.

244
00:37:17.340 --> 00:37:19.650
Ken Van Tilburg: orange orange sphere over there.

245
00:37:20.910 --> 00:37:28.050

Ken Van Tilburg: So it's just gross like it could not possibly be real, at least not for this type of signal, because it was already excluded by.

246
00:37:28.710 --> 00:37:34.380
Ken Van Tilburg: Other measurements so so other stellar cooling measurement So this is the same blocked electron company and photon coupling.

247
00:37:35.010 --> 00:37:48.210
Ken Van Tilburg: If you don't want to call stars at all you have to live in this Turquoise band and to fit their signal you need to live in the in the red band so engrossed violation of the schooling bounds so log plot so.

248
00:37:51.810 --> 00:38:01.560
Ken Van Tilburg: yeah these experiments can also look for for dark matter so if you assume these particles make up the dark matter you can you can look for them.

249
00:38:02.760 --> 00:38:18.090
Ken Van Tilburg: yeah and so so that would actually be a plausible explanation, so this excess of events was sort of this that the fact that the black line was above the Green and the yellow band, so their limit their limit on the on the coupling was worse than expected.

250
00:38:20.550 --> 00:38:26.280
Ken Van Tilburg: Okay, so so to summarize this this part so there's this.

251
00:38:27.330 --> 00:38:38.250
Ken Van Tilburg: Excess could be due to three populations so again, this is the same coupling plot of the electron coupling versus accion mess i'll just break it down slowly over time.

252
00:38:40.440 --> 00:38:52.740
Ken Van Tilburg: If it were a relativistic accion so mass list relativistic accion which was their signal interpretation they needed a coupling somewhere in this red band, which was in violation of these prior cooling constraints.

253
00:38:55.050 --> 00:38:56.580
Ken Van Tilburg: So that would correspond to.

254
00:38:57.870 --> 00:39:01.110
Ken Van Tilburg: yeah so sort of a this relativistic emission.

255
00:39:02.550 --> 00:39:06.540
Ken Van Tilburg: If it is, if the particle makes up the dark matter.

256
00:39:07.830 --> 00:39:19.620
Ken Van Tilburg: You know, we know its density and, in fact, a dark matter dark matter particles, you know, with the right energy with the right mask would explain the access, but my claim was that.

257
00:39:20.490 --> 00:39:32.760
Ken Van Tilburg: there's bound fraction is quite this bound density is quite high not quite as large as the dark matter density, but for similar coupling you could you could explain explain this excess.

258
00:39:34.590 --> 00:39:38.910
Ken Van Tilburg: And so yeah and so, and you could explain the access even if.

259
00:39:40.680 --> 00:39:45.180
Ken Van Tilburg: Even if the particle was was not dark matter, and because the density of this.

260
00:39:46.320 --> 00:39:52.470
Ken Van Tilburg: The Non relativistic solar based on population is higher I sensitive to smaller couplings.

261
00:39:54.780 --> 00:40:03.120
Ken Van Tilburg: And so now with the simulations, this is a new, updated results of where we've assumed if this financial.

262
00:40:04.170 --> 00:40:22.410
Ken Van Tilburg: accumulation time from from our simulation so So if you if you just if you're conservative and you take all the previous dark matter limits on this coupling you're going to recast it into this into this, a new limit independent of cosmology just from axioms produced by.

263
00:40:23.580 --> 00:40:29.130
Ken Van Tilburg: By the sun and and get a competitive limit it doesn't quite exceed.

264
00:40:30.210 --> 00:40:41.040
Ken Van Tilburg: The stellar cooling limits, however, this is insensitive to you know stellar evolution of red giants and white works which is somewhat complicated.

265
00:40:41.520 --> 00:40:57.630
Ken Van Tilburg: And furthermore, these experiments are improving, with time, in fact, now there's a xenon enten running we're Ennis six so they have a six times more sensitive experiment with three times lower background so in one year time this.

266
00:40:58.830 --> 00:41:05.790
Ken Van Tilburg: This excess will be under or falsified and also if they don't see anything that the limit will improve.

267
00:41:06.840 --> 00:41:08.040
Ken Van Tilburg: For this type of particle.

268
00:41:10.770 --> 00:41:21.030
Ken Van Tilburg: And so that's that's going to be the claim, so this solar basin or stellar basins in general will form the basis, I think, for for the leading prob.

269
00:41:21.510 --> 00:41:32.820
Ken Van Tilburg: Have any weekly coupled particle with a mass of around kV So in fact what i've shown you here was the simplest example, but not the most spectacular example.

270
00:41:34.230 --> 00:41:38.250
Ken Van Tilburg: So i'm going to show you a completely analogous example for.

271
00:41:39.840 --> 00:41:42.060
Ken Van Tilburg: A vector particle now she's.

272
00:41:43.140 --> 00:41:53.730
Ken Van Tilburg: not going to be too long, so that was the second paper you put out, so the this particle, so this is just a Maxwell lagrangian just for our photon.

273
00:41:54.270 --> 00:42:06.930
Ken Van Tilburg: Just imagine there's now a new photon F prime so a second dark photon that mixes with with our photon with some time by some tiny amount epsilon and this new photon has a mass as well.

274
00:42:08.730 --> 00:42:23.730
Ken Van Tilburg: So the production is very analogous except it can occur resident Lee so there's do some positive effects at low masses, you can

have resident production, and that makes the production much more dramatic by the sun.

275
00:42:25.320 --> 00:42:26.070
Ken Van Tilburg: So.

276
00:42:27.120 --> 00:42:36.270
Ken Van Tilburg: i'll skip this, but so in the end, these are analogous plot so so where the dark photon energy density in gv per centimeter cube.

277
00:42:36.750 --> 00:42:50.280
Ken Van Tilburg: can exceed the dark matter density, even for a couple things that are that we're still allowed and you can build up to this detailed balanced thermal occupation number in some cases.

278
00:42:51.390 --> 00:42:52.710
Ken Van Tilburg: And in this case.

279
00:42:54.330 --> 00:42:55.260
Ken Van Tilburg: Show you this limit.

280
00:42:56.490 --> 00:43:06.030
Ken Van Tilburg: In this case, now this solar basin, if you sort of re if you reinterpret existing dark matter experiments from the xenon collaboration.

281
00:43:08.310 --> 00:43:15.990
Ken Van Tilburg: In our work now based on our simulations we we get this new blue limit so over.

282
00:43:17.100 --> 00:43:24.660
Ken Van Tilburg: Quite a few orders of magnitude and in various places we set the best limit on on this new particle this simple.

283
00:43:25.230 --> 00:43:34.650
Ken Van Tilburg: vector particle mixed with our photon so in a small region here in a small region there in a big triangle here, where we improve the bounds by.

284
00:43:35.100 --> 00:43:46.530
Ken Van Tilburg: By an order of magnitude already with existing data and as in a corner over there as well, and again both of all of these bounds will improve so there's a an experiment running.

285
00:43:47.400 --> 00:44:01.200
Ken Van Tilburg: are being developed now being built now supersede dms that will be sensitive to very light dark matter and it will carve out a huge part of parameter space, even if this accident is not dark matter.

286
00:44:02.790 --> 00:44:05.100
Ken Van Tilburg: So yeah that's that's The bottom line on.

287
00:44:06.300 --> 00:44:10.620
Ken Van Tilburg: On direct detection, I want to leave some time for questions so i'm going to skip.

288
00:44:11.670 --> 00:44:17.430
Ken Van Tilburg: i'm going to give you just a brief summary of the next part, so this is direct detection on earth.

289
00:44:19.200 --> 00:44:24.480
Ken Van Tilburg: What what can also happen is just indirect detection so.

290
00:44:26.910 --> 00:44:42.990
Ken Van Tilburg: So what what can happen is so this base and density goes like one over radius to the fourth hour, so that the local density is appreciable but not very large like i've ordered the dark matter are a little bit less a little bit higher.

291
00:44:44.400 --> 00:44:53.880
Ken Van Tilburg: But near the surface of the sun, the density can be huge not so large that it gravitationally preserves the sun, but but very large.

292
00:44:54.960 --> 00:44:55.770
Ken Van Tilburg: Nevertheless.

293
00:44:56.790 --> 00:45:11.910
Ken Van Tilburg: And so what can happen or what may be observable is if these particles the cage two photons so you have a kV part mass particle that that is not an optimistic in the case, the two photons so you would get a line.

294
00:45:13.320 --> 00:45:18.630
Ken Van Tilburg: At half the rest at half the mass at half the energy of the rest mess energy of the particle.

295
00:45:21.480 --> 00:45:23.910
Ken Van Tilburg: yeah coming from near the surface of the sun.

296
00:45:25.170 --> 00:45:30.300
Ken Van Tilburg: With the known sort of spatial distribution with the limb brightened.

297
00:45:31.440 --> 00:45:44.790
Ken Van Tilburg: So what we've done is we we've used new star data to look at the limit of the sun so basically like a close to the surface of the sun, when the sun was very quiet and.

298
00:45:46.380 --> 00:46:04.710
Ken Van Tilburg: Our analysis should be out soon, so let me just show you the final sort of our energy or the final results, so this is the raw data of all of the photons collected in the field of you, the Red the red is sort of the the solar disk here.

299
00:46:05.970 --> 00:46:17.490
Ken Van Tilburg: And we look for as a signal, primarily in the limb, with some characteristics spectral and angular template so our actual signal.

300
00:46:18.780 --> 00:46:27.420
Ken Van Tilburg: I don't have it sorry I forgot the forgot the block, but our signal is sort of limbo at Brighton so it would be dominated here.

301
00:46:29.220 --> 00:46:29.640
Ken Van Tilburg: and

302
00:46:31.680 --> 00:46:44.520
Ken Van Tilburg: For this accion couple two photons we again so different coupling just a couple of photons we we set a limit that improves on existing constraints by by two orders of magnitude.

303
00:46:45.750 --> 00:46:55.320
Ken Van Tilburg: And, and this method will work for any type of star, so you can look for a stellar basins around white dwarfs neutron stars.

304
00:46:57.240 --> 00:47:04.650
Ken Van Tilburg: Hot super giants like beetle juice, where, which is much harder and can look for other particles so so.

305
00:47:06.060 --> 00:47:08.670

Ken Van Tilburg: yeah let me, let me, let me conclude.

306
00:47:09.690 --> 00:47:11.220
Ken Van Tilburg: Let me conclude, there so.

307
00:47:12.450 --> 00:47:13.020
Ken Van Tilburg: yeah I think.

308
00:47:14.430 --> 00:47:16.770
Ken Van Tilburg: stars can were known to be.

309
00:47:18.060 --> 00:47:37.200
Ken Van Tilburg: laboratories of new physics and we can look for direct detection of these a new particles so it's you know start the star is not only a laboratory that that produces produces these particles, but we can actually look for these particles in our laboratories as well.

310
00:47:38.700 --> 00:47:45.630
Ken Van Tilburg: But we can also look for them indirectly front from there X Ray the case, for example.

311
00:47:47.010 --> 00:47:58.830
Ken Van Tilburg: And not just around the sun, but better and other objects to which is going to be work that i'll be doing in the near future so Hello yeah i'll stop here, and thanks for your attention.

312
00:47:59.040 --> 00:48:00.540
Morgan Elowe MacLeod: happy to take any questions.

313
00:48:01.410 --> 00:48:01.770
Thanks.

314
00:48:05.940 --> 00:48:13.080
Morgan Elowe MacLeod: So maybe let's start online I I may Martin Elvis do you want to go ahead, so you had a question.

315
00:48:15.240 --> 00:48:15.480
Morgan Elowe MacLeod: And then.

316
00:48:16.080 --> 00:48:24.900
Martin Elvis: yeah I was just wondering, you can do direct detection close to the sun, if you get into a Parker solar probe type orbit and perry can you hear me.

317
00:48:25.500 --> 00:48:29.400
Ken Van Tilburg: OK, I can hear you yes it's a reason the tab as well.

318
00:48:29.490 --> 00:48:37.500
Martin Elvis: yeah couple of hundred thousand times the flux that you're get on earth so even a fairly small experiment might be useful yeah.

319
00:48:37.530 --> 00:48:39.630
Ken Van Tilburg: yeah we we we thought of that.

320
00:48:40.680 --> 00:48:54.090
Ken Van Tilburg: You can't quite get to yeah that if you if you could get to the solar surf this like really you know you wouldn't the like you say because it's one over to the fourth year 200 times closer, so you would get.

321
00:48:55.980 --> 00:49:12.030
Ken Van Tilburg: yeah almost 10 orders of magnitude or so nine orders of magnitude in density, it is a pretty extreme environment, though, and the probe does get radioactive as it gets close to the sun, with a lot of chart charged particles around.

322
00:49:12.090 --> 00:49:19.350
Martin Elvis: right but you're gonna have to get that close to gain five orders of magnitude and Parker solar probe is already demonstrated, it can be done.

323
00:49:20.160 --> 00:49:26.040
Ken Van Tilburg: yeah yeah so we have thought about it, we haven't done any analysis i'd be happy to.

324
00:49:27.510 --> 00:49:31.890
Ken Van Tilburg: collaborate with anyone or i'd be happy if someone else to be announced this too yeah and indeed.

325
00:49:33.630 --> 00:49:37.440
Ken Van Tilburg: An interesting thing that you could do let's say if it's 10 times closer to the sun.

326
00:49:38.700 --> 00:49:41.850
Ken Van Tilburg: You don't what we're looking for is the the.

327

00:49:43.050 --> 00:49:50.790
Ken Van Tilburg: You know the the the X Ray telescope new star is looking directly at the sun and the photons passed through.

328
00:49:52.770 --> 00:50:04.560
Ken Van Tilburg: The optical table and get get focused on on the sensor but where you could do with a probe like parks, is just close the aperture completely just have a box with insight.

329
00:50:05.280 --> 00:50:17.280
Ken Van Tilburg: shielded very well and have a sensor inside and look for a particle decaying inside inside your box and giving a signal there, so you don't necessarily need to focus.

330
00:50:17.730 --> 00:50:36.150
Ken Van Tilburg: If you're sufficiently close so that's an that's an interesting experiment, one could do, and as you say, also just real analyzing parks data could be interesting and I don't quite have a good sense of how competitive, it would be what the backgrounds are so so this.

331
00:50:37.230 --> 00:50:40.080
Ken Van Tilburg: New star observation was a particularly quiet.

332
00:50:41.280 --> 00:50:43.170
Ken Van Tilburg: Particularly quiet solid period.

333
00:50:45.030 --> 00:50:54.660
Ken Van Tilburg: So so new star specifically looked at the sun during this quiet diamond so so the limit that she has just done a very small data set of.

334
00:50:57.000 --> 00:50:59.730
Ken Van Tilburg: A few 1500 seconds I believed.

335
00:51:00.930 --> 00:51:03.180
Ken Van Tilburg: were just this this one orbit.

336
00:51:04.620 --> 00:51:16.920
Ken Van Tilburg: But, but you see here already, in this in this data there's some Spikes of events and that's when the new star satellite was passing through the South Atlantic anomaly so charged particles can.

337
00:51:17.520 --> 00:51:24.690

Ken Van Tilburg: give you access background I don't quite have a good idea with the the parks backgrounds are from charged particles, but I imagine they might be worse.

338
00:51:28.680 --> 00:51:29.940
Morgan Elowe MacLeod: David did you want to go ahead.

339
00:51:31.440 --> 00:51:37.860
David Michael Hernandez: yeah sure hi um I may have missed this, but for the bound axioms what's the initial.

340
00:51:38.940 --> 00:51:41.610
David Michael Hernandez: Like orbital distribution that you assume.

341
00:51:43.920 --> 00:51:48.540
Ken Van Tilburg: One King calculates so so basically.

342
00:51:50.700 --> 00:51:54.300
Ken Van Tilburg: there's a this this shape.

343
00:51:55.380 --> 00:52:03.180
Ken Van Tilburg: is universal for admission into a one over our gravitational potential and the reason is at.

344
00:52:04.980 --> 00:52:08.250
Ken Van Tilburg: yeah, so this is, I drive this in my first paper so.

345
00:52:09.930 --> 00:52:20.850
Ken Van Tilburg: You can write you can write this differential spectrum, just as a integrals over all the face face of all of the articles, but, including the accion So if you just extract.

346
00:52:21.540 --> 00:52:31.500
Ken Van Tilburg: This accion piece here and take the low momentum limit right you're interested in in just this sliver where it's very low velocity going out.

347
00:52:32.130 --> 00:52:48.180
Ken Van Tilburg: And so the instagram here completely is independent of K so, particularly at each point in the sun you emit into this 3D ball, you may you may uniformly into the ball.

348
00:52:48.690 --> 00:52:57.540

Ken Van Tilburg: Up to the escape velocity up to momentum, where you escape the solar system right from that so you know the initial injection trajectories.

349
00:52:58.650 --> 00:53:05.640
Ken Van Tilburg: And they give you an injection rate like this, so and that gives you these very, very radial orbits.

350
00:53:06.930 --> 00:53:10.230
Ken Van Tilburg: And in terms of semi major access distribution, it gives you.

351
00:53:12.360 --> 00:53:20.640
Ken Van Tilburg: One over a squared or as a semi major axis fractional distribution but otherwise sort of maximally isotopic.

352
00:53:21.750 --> 00:53:25.770
Ken Van Tilburg: Consistent with being emitted from maximally as a topic for each.

353
00:53:26.790 --> 00:53:28.800
Ken Van Tilburg: For each for each dimension.

354
00:53:29.490 --> 00:53:40.290
David Michael Hernandez: So I guess then i'm curious like in these long term like this plot, you have here this long term future axis evolution is your model just newtonian gravity.

355
00:53:41.880 --> 00:53:47.220
Ken Van Tilburg: yeah the model is newtonian gravity, but not one over our so one of the complications we.

356
00:53:48.480 --> 00:53:49.740
Ken Van Tilburg: had to deal with.

357
00:53:50.790 --> 00:54:01.980
Ken Van Tilburg: was the fact that them, but you know these are sun crossing orbits by by construction right you're admitted your emitted from the sun, so the orbits are not exactly clarion.

358
00:54:03.090 --> 00:54:07.890
Ken Van Tilburg: So this this piece here is in fact not exactly a equals zero.

359
00:54:09.000 --> 00:54:09.300
A.

360
00:54:10.410 --> 00:54:23.970
Ken Van Tilburg: it's the close to zero, but, but what can, what does happen is extremely rapid Perry helium procession because these particles are just going through the sun basically unperturbed but the potential is not one over are there, so you get these uh.

361
00:54:25.230 --> 00:54:30.990
Ken Van Tilburg: yeah rapidly processing patterns, they kind of look like we said you patterns very early on.

362
00:54:31.440 --> 00:54:42.720
David Michael Hernandez: So, so, then you did I did the reason I asked is because I know for mercury, including Dr effects, has a significant effect on stabilizing its orbit.

363
00:54:43.650 --> 00:54:49.140
David Michael Hernandez: So I guess that's what you mean when you say you change the potential like some GR effects right.

364
00:54:49.860 --> 00:54:51.120
Ken Van Tilburg: So um.

365
00:54:53.400 --> 00:54:55.530
Ken Van Tilburg: You know what I mean so.

366
00:54:56.130 --> 00:55:12.840
Ken Van Tilburg: While the effect to describe is also there and we have considered it we we so we didn't include GR effects and the long term simulations because, for most of the time they are small, for the orbits that we care about the ones that cross earth planetary perturbations are much larger.

367
00:55:14.460 --> 00:55:23.790
Ken Van Tilburg: But yeah initially when you're on these you know very low barrier Julian trajectories the potential is not one over our it has the one over our cube direction from.

368
00:55:24.420 --> 00:55:31.800
Ken Van Tilburg: Or maybe even one over R squared from from GR and also just the the sun is not appointed particle that's why it's not one over our.

369
00:55:32.550 --> 00:55:46.710
Ken Van Tilburg: that's by far the dominant thing, and I should also say we, we did analytic estimates before that not only this effect is negligible, but we also did not include in our long term simulations mercury.

370
00:55:47.940 --> 00:55:50.580
Ken Van Tilburg: or Mars or Neptune or uranus because they'd be.

371
00:55:51.600 --> 00:55:55.500
Ken Van Tilburg: They give negligible contribution, so we have a slide here.

372
00:55:57.360 --> 00:55:58.380
Ken Van Tilburg: i'm going to show you here.

373
00:56:02.790 --> 00:56:03.540
Ken Van Tilburg: This is.

374
00:56:05.340 --> 00:56:05.910
Ken Van Tilburg: A.

375
00:56:07.470 --> 00:56:12.000
Ken Van Tilburg: sort of short time scale analysis, where we look at.

376
00:56:12.570 --> 00:56:21.420
Ken Van Tilburg: The chain, the fractional change and semi major access for positive one, so sort of up scattering where you increase the energy and down scattering where you decrease the energy.

377
00:56:21.870 --> 00:56:41.340
Ken Van Tilburg: And so we we basically see that as a function of semi major axis and the changes over 1000 years so so basically what happens is that anything that crosses jupiter's orbit which is this line years so gets kicked out very quickly.

378
00:56:44.370 --> 00:56:54.660
Ken Van Tilburg: But for orbits in the inner solar system Jupiter just give secular perturbations for the most part and and changes the angular momentum of the orbits especially.

379
00:56:55.650 --> 00:57:13.860

Ken Van Tilburg: Alex and ally and the planets in particular Venus and earth are the dominant ones, to give sort of chaotic kicks so random kicks and they change lc and so so yeah so we we think and we're doing some some.

380
00:57:15.210 --> 00:57:20.670
Ken Van Tilburg: Mark off process analysis now where basically we think the final answer.

381
00:57:22.350 --> 00:57:29.880
Ken Van Tilburg: You can get from from taking these sort of short timescale scattering processes and making a mark off matrix out of this.

382
00:57:30.810 --> 00:57:45.480
Ken Van Tilburg: squaring it a bunch of times and after a billion, after many iterations you get an evolution that's that's quite consistent it doesn't capture of course everything like emotional resonances but, but he captures sort of the broad features of.

383
00:57:46.530 --> 00:57:51.360
Ken Van Tilburg: Of the evolution so it's mostly close encounters from Venus and earth.

384
00:57:52.860 --> 00:57:53.370
Ken Van Tilburg: and

385
00:57:55.320 --> 00:58:00.030
Ken Van Tilburg: And yeah secular perturbation from from Jupiter and in fact I don't think I have it here.

386
00:58:01.140 --> 00:58:09.180
Ken Van Tilburg: No, I don't but, but you can calculate close encounters just from the gravitational scattering cross section and the plot looks exactly the same.

387
00:58:09.990 --> 00:58:19.320
Ken Van Tilburg: module of these Spikes which a close encounter analysis cannot take into account for emotional resonances yeah we think we understand what the what happens.

388
00:58:19.800 --> 00:58:24.900
David Michael Hernandez: Thanks yeah I think someone else has a question i'd have more questions but.

389

00:58:24.930 --> 00:58:31.290
Morgan Elowe MacLeod: yeah, we need to stop there, for now let's think can all together, one more time.

390
00:58:34.530 --> 00:58:39.660
Morgan Elowe MacLeod: Can I know that you have a lecture to get to, but if you can stay for a few more minutes on the call, we do have.

391
00:58:39.960 --> 00:58:43.770
Ken Van Tilburg: One more question yeah yeah for sure for sure I could say I could say well.

392
00:58:44.970 --> 00:58:45.090
Ken Van Tilburg: You.