

WEBVTT

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00:00:01.680 --> 00:00:10.080

Morgan Elowe MacLeod: So today it's my pleasure to welcome NHS and and it is joining us from the Albert Einstein Institute.

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00:00:12.240 --> 00:00:13.799

Morgan Elowe MacLeod: Or would.

3

00:00:13.889 --> 00:00:17.520

Anna Ijjas: Actually, actually, right now, from here, but officially from the other time.

4

00:00:17.699 --> 00:00:19.410

Morgan Elowe MacLeod: Exactly exactly.

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00:00:20.850 --> 00:00:30.630

Morgan Elowe MacLeod: And we're we're delighted to to get to learn from you today, so I thought the early universe so we'll take it away, thank you.

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00:00:30.780 --> 00:00:33.090

Anna Ijjas: Thanks very much Morgan it's great to be here, oh by.

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00:00:33.480 --> 00:00:34.530

Anna Ijjas: Only where your screens.

8

00:00:35.610 --> 00:00:45.000

Anna Ijjas: Just an addition to Morgan and also because they have coins, I can hopefully facilitate if you have any questions you know it doesn't have to be strict.

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00:00:45.300 --> 00:00:53.520

Anna Ijjas: I prepared a talk when maybe questions come up at any point that should not be technical and it should be, hopefully, something that you normally don't think about that often since it's.

10

00:00:53.760 --> 00:01:06.780

Anna Ijjas: A little bit further away from normal astrophysics and vice versa theoretical cosmology please interrupt me at all, should be in the sense informal that nobody should feel like you know it should go immediately chat or or you don't want to call you have a question just.

11

00:01:06.960 --> 00:01:13.230

Anna Ijjas: Just just please unmute yourself and ask your question i'm more than happy to give this To that extent, informal.

12

00:01:13.530 --> 00:01:15.120

Anna Ijjas: And I should probably apologize.

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00:01:15.150 --> 00:01:17.250

Anna Ijjas: If the transcript doesn't come through that about.

14

00:01:17.460 --> 00:01:21.180

Anna Ijjas: Obviously I haven't accepted it's not optimized for accidents, but I hope that those.

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00:01:21.180 --> 00:01:23.250

Anna Ijjas: who need it, but nevertheless can follow it through that.

16

00:01:23.550 --> 00:01:31.140

Anna Ijjas: Good so do they stop it could be i'll be an issue that is important, or at least I hope to convince you.

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00:01:31.740 --> 00:01:41.790

Anna Ijjas: At the end of this color units important but very often neglected in cosmology, and this is the issue of the, how do we explain the.

18

00:01:42.480 --> 00:01:53.550

Anna Ijjas: entropy in the early universe, which is very low, as opposed to today when it's very high and height my car focusing more on this problem.

19

00:01:54.390 --> 00:02:03.930

Anna Ijjas: might help us answer questions about the early universe, and perhaps maybe a universe as a whole it's evolution and origin, even today or in our future.

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00:02:04.920 --> 00:02:12.810

Anna Ijjas: That we otherwise would not figure, so it should be an additional arguments to buy to think out of the box and cosmology.

21

00:02:13.590 --> 00:02:21.360

Anna Ijjas: From from up from up from a new by the word point of view so let's just do to put everybody in the same stage, we all know, this picture.

22

00:02:21.810 --> 00:02:28.140

Anna Ijjas: Perhaps it with a little modification, but this is our van or lamb the cdn cosmology that we all love and understand.

23

00:02:28.860 --> 00:02:41.160

Anna Ijjas: that many of us working on different parts of in some at local university at Richard zero some back in time and some of us, including me that are some very, very it's not even on the picture.

24

00:02:42.360 --> 00:02:54.270

Anna Ijjas: Here, so, but what we know is that the fairly well understand in terms of Lambda cpm and using the equations of relativity and and often even getting by etonian physics.

25

00:02:55.380 --> 00:03:00.780

Anna Ijjas: You really can bad describe the last 13.8 billion years of expansion.

26

00:03:02.130 --> 00:03:03.660

Anna Ijjas: Using our telescopes.

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00:03:04.770 --> 00:03:11.040

Anna Ijjas: And satellites and other kind of measurements and we also knew that you don't understand.

28

00:03:11.400 --> 00:03:20.070

Anna Ijjas: Really value what happened in the first, second so, even though we call them the cdn often sloppily big bang cosmology just because this is the name that it got.

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00:03:20.370 --> 00:03:26.610

Anna Ijjas: We really don't know what happened, really, what happened before the first, second what we know is that we have a hint.

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00:03:27.030 --> 00:03:35.520

Anna Ijjas: And the hint is coming from the cosmic microwave background or from the last scattering surface that tells us that that tells us how the universe look 400,000 years.

31

00:03:35.820 --> 00:03:41.580

Anna Ijjas: After our hard big Ben is spent by extension era started and what we really.

32

00:03:42.150 --> 00:03:50.940

Anna Ijjas: Learn from from the microwave background is as we believe how the universe might have looked around one second after the highest expansion started.

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00:03:51.780 --> 00:03:55.620

Anna Ijjas: Now you notice I try to stay hot expansion not big bang expansion, since.

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00:03:56.220 --> 00:04:07.170

Anna Ijjas: One of my point is, and this is really probably just something that we all know about often forget, including myself, that we really don't know we don't have a theory of the big bang So even if actual.

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00:04:07.500 --> 00:04:15.120

Anna Ijjas: Actual I think backwards in time, which is a huge extrapolation from the very first second to somebody into quantum gravity era.

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00:04:15.870 --> 00:04:29.490

Anna Ijjas: into it and believe that somehow everything emerged in terms of a big bang we don't know his description short of a full description of quantum gravity and therefore we should really keep an open mind that might not be when the bestest dictionary, it might be that if we find.

37

00:04:29.700 --> 00:04:32.010

Anna Ijjas: The two theory of quantum gravity to tell us.

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00:04:32.100 --> 00:04:41.730

Anna Ijjas: It might not be the best idea to have a big bankruptcy and for both me to have a big bang so whatever it is, it has a problem it poses as a problem of.

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00:04:42.180 --> 00:04:46.350

Anna Ijjas: What we see from the microwave background, as opposed to how the only way or the universe should look like.

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00:04:46.620 --> 00:04:54.480

Anna Ijjas: And there are a lot of features that we all know, and all hear about this coffee and won't be about was features, but just to recap the first of all, and all that our universe.

41

00:04:54.780 --> 00:04:57.810

Anna Ijjas: born a baby universe, but even a large scales today.

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00:04:58.260 --> 00:05:06.720

Anna Ijjas: Not not not not not on small scales better structure, every week, we have such a rich structure is smooth and flat and Nice more time minutes, and as a topic and.

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00:05:06.960 --> 00:05:17.760

Anna Ijjas: and homogeneous, so it doesn't matter value look which direction you look, you should always see the same and the irs the by 500 megapixel i'd really i'm talking about you sales.

44

00:05:18.060 --> 00:05:21.780

Anna Ijjas: And it's not like this to our the evolution of the universe.

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00:05:22.200 --> 00:05:29.460

Anna Ijjas: and moreover adobe know because that's not the picture that you usually see from the microwave background, of course, the picture that you usually see as this one.

46

00:05:29.820 --> 00:05:37.470

Anna Ijjas: But this is really wanted to be sure how good we are at resolving temperature and I set up this is what we know is that the average temperature is.

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00:05:37.920 --> 00:05:42.360

Anna Ijjas: That nearly every there, but the average time to absolutely everybody, as far as we can measure it.

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00:05:42.870 --> 00:05:55.440

Anna Ijjas: 2.7 Calvin and what we see here is if we see that we find the first deviations from the average temperature and we know we have to zoom in by hundred thousand and so it's 1.8 hundred thousand or hundred thousand times.

49

00:05:55.980 --> 00:06:02.160

Anna Ijjas: magnification of the microwave background temperature map and we know that the higher than a cost but really signals.

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00:06:03.450 --> 00:06:20.370

Anna Ijjas: amplitude of Center minus five deviations, we also know from measurements that the spectrum is nearly scale and very and and and the only go soon and we also know that this is as far as we can see and that's thanks to the latest is actually a pretty amazing bands now on the.

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00:06:20.550 --> 00:06:21.870

Anna Ijjas: On the gravitational wave.

52

00:06:22.590 --> 00:06:35.070

Anna Ijjas: buzzer amplitude possibly coming from the universe thanks the latest bicep kak released, just a few weeks ago, we know it's very, very low, so as far as we can see, we have an issue say yet that active.

53

00:06:36.150 --> 00:06:41.790

Anna Ijjas: And might have to make a very long time the attack or we will never defect windows.

54

00:06:42.420 --> 00:06:53.040

Anna Ijjas: gravitational base that side so exciting from the early universe So these are the features that normally they focus on, then we talk about the early universe, or about the salient features of our universe.

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00:06:53.370 --> 00:06:57.720

Anna Ijjas: What we do have learned during I would say the past 40 years that.

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00:06:58.470 --> 00:07:11.880

Anna Ijjas: If we can explain this picture if we can get a flattened smooth universe, then, and this is amazing, I really think that this is, this is the main achievement of the past 40 years early universe cosmology we know how to generate this.

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00:07:13.980 --> 00:07:22.680

Anna Ijjas: temperature spectrum, which we believe is seated by some sort of quantum fluctuations in the early universe, that you are by the smoothing mechanism in fact.

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00:07:23.130 --> 00:07:34.320

Anna Ijjas: That the universe, and I will talk today about two kinds of moving mechanism that that that would put these models, which are of quantum origin, and we are the universe super super humble scales.

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00:07:35.820 --> 00:07:45.750

Anna Ijjas: are many, many to be completed precise answer 28 super hubble's chaos that then then after this whatever primordial phase enter the horizon, see the.

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00:07:46.170 --> 00:07:57.750

Anna Ijjas: temperature fluctuation gravitation and stability and structure, so this is a nice story of early universe, and I would believe that the last 40 years we all have focused on this, but the sun was neglected some other questions that point or was bad.

61

00:07:58.770 --> 00:08:02.730

Anna Ijjas: But set the primordial phrase that that That said, the fluctuations.

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00:08:03.060 --> 00:08:09.360

Anna Ijjas: How do we describe the big bang, do we really have a good theory of initial conditions because, in order to support and flatten V realize.

63

00:08:09.600 --> 00:08:18.420

Anna Ijjas: Whether we talk about as revealing the second inflation or other kind of ice and at least two inflation renewed at a primordial mechanisms that relative or sensitive.

64

00:08:19.260 --> 00:08:30.300

Anna Ijjas: monk would say if it was to my exponentially sensitive to the initial conditions so universe, if you assume a big band comes out of the big bang so so we have to go back to the drawing board, so to speak, we took.

65

00:08:31.140 --> 00:08:40.530

Anna Ijjas: This was a hard question to extend an isotope is, and it was a hard question, but now that we have a good mechanism it's time to go back to the drawing board for the other question that might might have seemed.

66

00:08:41.100 --> 00:08:50.820

Anna Ijjas: Easier second thing is what you might never think about it, even have to explain why the universe is classical to come out of quantum big bang, and lastly, and this will be our.

67

00:08:51.840 --> 00:09:01.260

Anna Ijjas: topic for the remainder of the talk, how do we explain this very particular feature of the early universe, that is very unexpected here Victoria alley.

68

00:09:01.980 --> 00:09:05.190

Anna Ijjas: For for the quantum big bag, if you come out of quantum big bang.

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00:09:05.550 --> 00:09:15.450

Anna Ijjas: There if it's a big bang, it has to be a quantum big bang that all the degrees of freedom in particularly with this is expected gravitation or degrees of freedom are excited.

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00:09:15.660 --> 00:09:22.560

Anna Ijjas: Because, why should they not be so hugely highly energetic event shaking or degrees of freedom that's that's the default as either effect.

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00:09:23.490 --> 00:09:39.390

Anna Ijjas: This is very assume the big bang entropy problem starting, as pointed out early as 1989 by Penrose that first of all, we would expect large entropy entropy entropy distribute important the gravitational and the stress energy or simplistic mother sector.

72

00:09:40.020 --> 00:09:53.070

Anna Ijjas: But what we see or can conclude from from very are today is that the total entropy is in fact tiny, the only universe and it's not in the gravitational sector if you assume that, for the.

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00:09:53.760 --> 00:10:03.810

Anna Ijjas: purposes of the next to say don't assume any type of inflation so coming out of the usual hot big band that gave rise, which is fine tuning problems to be emergence of inflation.

74

00:10:04.170 --> 00:10:09.600

Anna Ijjas: If you come out of that big bang what happens for some reason the universe choose not to excite.

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00:10:09.780 --> 00:10:21.570

Anna Ijjas: The the gravitational degrees of freedom and in hot big bang cosmology or entropy is are stored in the mother radiation sector, of course, this is very much opposed to hide looks today, since today.

76

00:10:21.840 --> 00:10:27.930

Anna Ijjas: or entropy is stored in form of back end scene and European in in in supermassive black horse, so we have to get there, somehow.

77

00:10:28.980 --> 00:10:47.370

Anna Ijjas: From the other radiation sector leads entirely into the gravitational sector we don't quite understand assuming a big bank hide got there now, you might think, or you should think that if you if you go with the standard picture, then you have to ask about can inflation.

78

00:10:48.660 --> 00:10:58.620

Anna Ijjas: hypothetical phase that should have taken place after the hot big bang or after the big bang in terms of the single out to a quantum gravity Iraq.

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00:10:58.950 --> 00:11:05.160

Anna Ijjas: And before nuclear synthesis that the universe was supposed to be flattened and smoothing to.

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00:11:05.550 --> 00:11:11.760

Anna Ijjas: phase of accelerated extension can inflation, so this question and the simple answer is no, it cannot.

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00:11:12.150 --> 00:11:22.020

Anna Ijjas: and inflation was not introduced to solve this question by the inflation gives a good example by one might be able to solve the whole magenta and flatness problem, the horizon problem.

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00:11:22.260 --> 00:11:29.820

Anna Ijjas: And might be able to explain the fluctuation or at least give us a story for description of how the fluctuation might have emerged without.

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00:11:31.110 --> 00:11:40.770

Anna Ijjas: adding to the entropy problem, as a matter of fact, what happens really is in inflation that because we introduced this inflict and now you go from.

84

00:11:41.430 --> 00:11:47.910

Anna Ijjas: The all the entropy bringing in stuff stolen another radiation sector and not in the gravitational sector.

85

00:11:48.330 --> 00:11:53.340

Anna Ijjas: what's happening is, you cannot sword sword initiative, the partition problem becomes even more peculiar.

86

00:11:53.610 --> 00:12:03.780

Anna Ijjas: Since now what entropy has to be even the matter radiation sector, the entropy has to be suppressed after after the the quantum gravity or and in the gravitational sector and all entropy has to be.

87

00:12:04.200 --> 00:12:14.460

Anna Ijjas: A uniform is toward and and by entropy really if you think why she really mean for the purposes of this talk is shouldn't have to say, but degrees of freedom are excited.

88

00:12:14.790 --> 00:12:23.850

Anna Ijjas: And the interesting thing that the only degrees of freedom that I excited I just can I feel degrees of freedom to inflict on degrees of freedom that should be driving this excellent and expansion.

89

00:12:24.540 --> 00:12:28.890

Anna Ijjas: Having a dark energy like equation of State so w being close to minus one.

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00:12:29.700 --> 00:12:38.040

Anna Ijjas: sample it was the sitter like space and that's even more peculiar because now, you have to explain why there isn't one drop in the mother radiation sector either.

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00:12:38.460 --> 00:12:43.590

Anna Ijjas: And you also have to explain by enterprise so homogeneous distributed in this killer.

92

00:12:43.920 --> 00:12:53.100

Anna Ijjas: And Penrose quantified is, and this is something that nowadays, you might hear about a lot since since gone the Nova he goes around calling a lot about this story, and he.

93

00:12:53.370 --> 00:13:00.180

Anna Ijjas: just mentioned, you know they might have different points of views about his suggestion, how to solve this problem, can you confirm a cyclic cosmology.

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00:13:00.540 --> 00:13:08.460

Anna Ijjas: However, the problem that we pointed out, already in the late 80s it's really an important problem, I think it should be that taken that inflate so the big.

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00:13:08.940 --> 00:13:21.870

Anna Ijjas: Big Bang cosmology hasn't entropy problem, both in terms of the low entropy and the strange partition of the entropy, but if you act that inflation that makes the problem even even if it's a good solution for the homogenized flatness.

96

00:13:23.370 --> 00:13:39.030

Anna Ijjas: And and horizon problems and can explain the fluctuations, it makes the entropy problem that some candles both in the stainless paper and 89 at inflation gets nowhere close to solving the initial conditions problem, he means inflation makes the initial entropy problems worse now.

97

00:13:40.830 --> 00:13:49.950

Anna Ijjas: Admittedly, this problem was not in the Center of attention, since October 1 let's explain the cosmic microwave background that's more important, we can measure it this made or natural issue.

98

00:13:50.430 --> 00:14:00.540

Anna Ijjas: But I believe is really important mad at we have some good description, and we know that what we need is quantum fluctuation some mechanism that can put them on super horizons yes.

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00:14:00.810 --> 00:14:08.400

Anna Ijjas: And what we really need is is go back to question that might tell us about the smoothing mechanism might be perfect referred by observations.

100

00:14:08.670 --> 00:14:14.340

Anna Ijjas: and also by other questions that are natural i've been neglected, if you want to have a flow theory of the origin of the universe.

101

00:14:14.670 --> 00:14:23.940

Anna Ijjas: And Penrose is our main claim and that's what i've been getting the next second is to take it very seriously, it might be a problem is the big bang.

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00:14:24.690 --> 00:14:35.160

Anna Ijjas: It might be that it will be very difficult, if not impossible to solve this problem as long as we assume that spacetime emerged from a quantum form or a quantum gravity stage.

103

00:14:35.460 --> 00:14:43.410

Anna Ijjas: Because that might not, and this is what actually seems really strange model, because what have come from a cyclic has money because it wants to say yes.

104

00:14:43.680 --> 00:14:50.250

Anna Ijjas: And he mentioned that a lot, so I just want to give you a context which point I believe is very valid and which part is very speculative at this stage.

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00:14:50.640 --> 00:15:03.270

Anna Ijjas: Now you mentioned oh um I came to the conclusion that the big bang cannot be quantum gravity that comes from that it really cannot imagine, and he might have a point here that.

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00:15:04.290 --> 00:15:14.940

Anna Ijjas: Fully quantum gravity beginning to ever be able to explain how you relax the gravitational degrees of freedom and store everything either no matter radiation sector or some sort of important sector.

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00:15:15.240 --> 00:15:19.140

Anna Ijjas: I think this question is right now open so it's very important to take it seriously from.

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00:15:19.410 --> 00:15:28.080

Anna Ijjas: That that point if you work on the big bang but but i'm going to show you today is is a different picture that might already be closer to solving this problem.

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00:15:28.290 --> 00:15:36.090

Anna Ijjas: or at the very least, provides a good alternative picture to the very hard problem that we have been struggling literally took on this since the 1970s.

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00:15:36.750 --> 00:15:39.180

Anna Ijjas: To unite quantum physics and and and.

111

00:15:40.110 --> 00:15:52.830

Anna Ijjas: General activities after about 100 years of struggle, I think it's it's definitely on the time to to look at something that might be a good alternative and might be decided by astrophysical and cosmological observations.

112

00:15:53.400 --> 00:16:03.990

Anna Ijjas: And what I want to start is is this idea that they have to do to problems So how do we have, first of all, a low entropy states or what makes the entropy density, similar to the.

113

00:16:04.290 --> 00:16:09.060

Anna Ijjas: amount of entropy within our observable hubble pat's more for the beginning of the.

114

00:16:09.330 --> 00:16:18.870

Anna Ijjas: Of let's say by nuclear synthesis of the radiation domination era there's the one question, so we need to first of all, a mechanism, whatever mechanism that that shrinks the entropy density.

115

00:16:19.380 --> 00:16:28.650

Anna Ijjas: that's that's how you know i'm a few years, so I started Okay, which question might, may I may be able to attack source, but maybe the simplest part of the problem.

116

00:16:29.040 --> 00:16:31.740

Anna Ijjas: And then the question is okay, if I find such a mechanism.

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00:16:32.490 --> 00:16:41.880

Anna Ijjas: Is it possible that that mechanism actually can resolve the problem or can truly be the the mechanism that says the initial data or the initial conditions for hot big bang evolution.

118

00:16:42.090 --> 00:16:47.100

Anna Ijjas: Or, I would say hot expansion, so I think being evolution is something without the bank it's never cpm.

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00:16:47.400 --> 00:16:56.910

Anna Ijjas: Or, more precise that probably should just call it caught extension, as we know it, so the last 13.8 billion years so and, and this is, this is an idea of course I don't come through it.

120

00:16:57.870 --> 00:17:07.140

Anna Ijjas: Without without previous interest this isn't, this is an idea that that that I have been interested in for a long time in the fact.

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00:17:07.950 --> 00:17:15.990

Anna Ijjas: That the universe might have emerged from other band, but the transition from an earlier contracting phase that we often call a bounce.

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00:17:16.380 --> 00:17:24.540

Anna Ijjas: And I would say that in the last two or three years in a very interesting progress on the side you're making the idea at least to the scooting.

123

00:17:25.470 --> 00:17:34.920

Anna Ijjas: With disrespect of smoothing face a sharper and that's why he also understood a lot about it hi might have with the entropy problem so at that time is a little bit about the basics.

124

00:17:35.160 --> 00:17:52.230

Anna Ijjas: I have fear about 15 more minutes of this idea and hide the fact the entropy problem encoding little bit touching on a progress made and afterwards, with any point, you know if you have questions or or or any points we can return, and you can let me say more about one part of the other.

125

00:17:53.730 --> 00:18:03.330

Anna Ijjas: Okay, so what is the idea of so contraction oh I tend to say that snow contraction is very much the idea that probably would not have emerged.

126

00:18:04.170 --> 00:18:14.340

Anna Ijjas: without our knowledge about inflation and had imagined it flattering and supporting the universe and that's nice I believe it's not not not not by accident that the same people who were.

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00:18:15.150 --> 00:18:18.540

Anna Ijjas: instrumental in proposing and developing the idea of inflation.

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00:18:18.900 --> 00:18:25.500

Anna Ijjas: came up with this idea I don't really think that they had to be that unhappy with inflation to come up with this idea it's just good science to see.

129

00:18:25.740 --> 00:18:32.220

Anna Ijjas: Oh, the idea of it, so it works in one context also works in other contexts might have good good implications for the context and.

130

00:18:32.490 --> 00:18:38.490

Anna Ijjas: Here, of course, I talked about last time hood and collaborators need to rock quarry of food and so on in the early 2000s.

131

00:18:38.880 --> 00:18:46.350

Anna Ijjas: who showed us that, if we have a face to face and virtual universe for street for site at a very low energy very low temperature.

132

00:18:46.800 --> 00:18:53.790

Anna Ijjas: Really low temperature I could be a temperature today and a huge hubble patch so because the radius.

133

00:18:54.720 --> 00:18:59.610

Anna Ijjas: And and very low energy, as we know that they are inversely proportional one other thing I was working on minutes.

134

00:18:59.940 --> 00:19:07.920

Anna Ijjas: And the public is just usually that ovary or the logarithmic time derivative off of off of the scale factor which I had noted a then.

135

00:19:08.370 --> 00:19:12.870

Anna Ijjas: By the of using general activity which is new, leading to a beautiful relation in a.

136

00:19:13.320 --> 00:19:22.200

Anna Ijjas: spiritual semantic or flattened smoot universe or Friedman Roberts and for our universe, just as the Einstein equations really reduced to this very, very simple relation.

137

00:19:22.680 --> 00:19:30.270

Anna Ijjas: As it is, this is worth any fans is true for if you introduce inflation that was that was the underlying idea of inflation, as proposed by Google.

138

00:19:30.630 --> 00:19:38.250

Anna Ijjas: and others, and then it also underlying the slow contraction, but we can also decide the radiation and the and the mother dominated dark energy dominated.

139

00:19:38.490 --> 00:19:44.490

Anna Ijjas: By just the simple relation only if you are interested in how the hubble patch which we can think of as some some.

140

00:19:45.390 --> 00:19:58.620

Anna Ijjas: During the matter radiation Iraq is is to with approximation of horizon, otherwise you have to be a little bit cautious and say that the hubble radius is too good approximation, the scale of causal interactions again i'm not here it's.

141

00:19:58.620 --> 00:20:00.000

Anna Ijjas: For the purposes of this talk and.

142

00:20:00.180 --> 00:20:03.120

Anna Ijjas: As as pedestrian with the definition as I can.

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00:20:04.710 --> 00:20:07.980

Anna Ijjas: And then, but general activity tells us that in general.

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00:20:09.990 --> 00:20:20.550

Anna Ijjas: How the hubble reviews evolves is different from have physical esky as he represented by the scare factor was doing both expansion and contraction and there's.

145

00:20:20.970 --> 00:20:23.430

Anna Ijjas: Different a wreath of evolution.

146

00:20:23.430 --> 00:20:34.980

Anna Ijjas: At a different rate of expansion of the causal interactions care versus the physical scares is all imprinted into our stress energy, but then a homogeneous and as a Tropic background the stress energy is.

147

00:20:35.370 --> 00:20:38.310

Anna Ijjas: He I just very much Jason a little bit different than you are you doing you're still.

148

00:20:39.030 --> 00:20:49.080

Anna Ijjas: But it's all imprinted into an effective equation of states which which we can assign to any form of math or any form of stress energy to scale a fiesta matter to radiation and so on.

149

00:20:49.380 --> 00:20:58.950

Anna Ijjas: It is just the usual to take up a component then it's a simple here three has one plus, as you know it w so w is pressure over energy density or for the main component.

150

00:20:59.190 --> 00:21:07.320

Anna Ijjas: And so just a reminder for inflation, it would be that absolutely it's very small it's more than one to a girl was very fast by each.

151

00:21:08.250 --> 00:21:15.900

Anna Ijjas: inverse of the hubble radius is is is is nearly constant so some people also put the sitter evolution of the sitter like evolution, the closer.

152

00:21:16.380 --> 00:21:25.980

Anna Ijjas: To zero that you can see, it requires w close to minus one, and this is exactly what's it like we have to be, and that we know this accident expansion and snow contraction acts differently.

153

00:21:27.000 --> 00:21:38.010

Anna Ijjas: Because what we want here is twofold So the idea is to flatten and smooth the universe and super humble scales so in particular here I focused on how do we make a right kind of patch.

154

00:21:38.220 --> 00:21:48.930

Anna Ijjas: Which is really smooth inside one have a patch and the fluctuations emerging from this better support hubble this is happening, and this relationship devalue important for the entropy to this is happening by.

155

00:21:49.710 --> 00:21:55.680

Anna Ijjas: Inflation you would just let everything rush out of your hub patch right you keep the hubble patches.

156

00:21:56.250 --> 00:22:03.330

Anna Ijjas: size of your elbow patches nearly constant by in snow contraction opposite is happening it's slow, because as soon as very big.

157

00:22:03.750 --> 00:22:10.860

Anna Ijjas: It can be three or higher, as a matter of fact, I will show you examples in a second very numerical simulated the space very it's very, very big.

158

00:22:11.160 --> 00:22:22.590

Anna Ijjas: What happens is and that's a contraction is slow it's very counterintuitive to what we usually know about newtonian contraction every you think it's crunches matter what actually happens physical distances hardly change.

159

00:22:24.150 --> 00:22:31.110

Anna Ijjas: A is nearly remaining constant and the bigger absent, is the quicker the hubble radio shrinks and on it and that's hot things that were.

160

00:22:31.380 --> 00:22:39.060

Anna Ijjas: Connected before causally become khosla disconnected and just want to have an imagined this one imagines is typically in cosmology is.

161

00:22:39.300 --> 00:22:47.250

Anna Ijjas: supplied by a scale of field, and we know that if you are, for example, schillaci, which is an exponential potential either characteristic no just kill off of.

162

00:22:48.120 --> 00:22:56.640

Anna Ijjas: Mass scale and for the few that we can we can solve the freedmen equations exactly a pencil and paper, which is a very good first student exercise.

163

00:22:57.990 --> 00:23:06.450

Anna Ijjas: But we always give our students, both in classes and then they start to do graduate research with us, one is a beautiful is either one can the free market.

164

00:23:07.410 --> 00:23:14.970

Anna Ijjas: Solutions already an exact solution of the Einstein activations and if you add you know can only scale up an exponential potential you get another exact solution.

165

00:23:15.240 --> 00:23:24.390

Anna Ijjas: That my beloved input in anytime in customers to start with this, you have a good understanding from exponential potentials it's usually a good understanding it from one I have more bedrock models.

166

00:23:24.600 --> 00:23:35.370

Anna Ijjas: Or, more precise models and then, when find that the very interesting relationship as possible name of this equation of status given by one or two times and clear it, you see, if you take, for example, just you I just.

167

00:23:35.700 --> 00:23:42.630

Anna Ijjas: characteristics care of your potential would be typically as particle physicists features point 1.21 we have huge excellence so typically.

168

00:23:42.840 --> 00:23:55.830

Anna Ijjas: During 64 of of contractions know contraction to black was hardly move towards one another, so that the physical skills shrink bierhoff to their size, by the hub radio shrinks by to the 50 but to the 60 times.

169

00:23:56.700 --> 00:24:02.790

Anna Ijjas: To the 64 so you really got huge batch then, if you want to really see this, so why is it interesting for the entropy.

170

00:24:03.270 --> 00:24:16.950

Anna Ijjas: First of US moves in certain so the universe that's important but second I shrinking the hubble radius what you do is you shrink the entropy density your patch cliff was the thing that that I told you, you should watch out for, and if you want to know, have valid smooths so.

171

00:24:18.330 --> 00:24:25.200

Anna Ijjas: For for one minute just look at it, we get a lot of work on this, and this is my main focus, but it won't be the main focus of my talk.

172

00:24:25.470 --> 00:24:29.100

Anna Ijjas: Funk and actually caught up the Einstein equation, I guess, in this nice limit.

173

00:24:29.460 --> 00:24:36.060

Anna Ijjas: But one can really solve them just one can solve them for the emergence of of binary black was a neutron stars and neutron stars backhoes.

174

00:24:36.420 --> 00:24:46.530

Anna Ijjas: And simulated for completed general initial data when you come very far away from my for w and what i've your plot here is a diorama goes to the normalized energy density of anisotropy.

175

00:24:47.280 --> 00:24:55.800

Anna Ijjas: curvature and at a scale of field, energy and just to show your session what you will see everything quickly flattens out and the scale of it comes to dominate.

176

00:24:57.480 --> 00:25:04.410

Anna Ijjas: You see, this is that quickly, everything is it's a simulation on works and I usually say four years never gets boring resides.

177

00:25:05.250 --> 00:25:15.300

Anna Ijjas: happened so quickly, but she was really had power for this this mechanism so since it happened so quickly, I usually slow it down by 25 for demand and what you get this.

178

00:25:15.660 --> 00:25:19.140

Anna Ijjas: You see, within order of money for to get the universe, as you want to see it.

179

00:25:19.440 --> 00:25:27.900

Anna Ijjas: And everything what's happening afterwards it's just imprinting this fatness and and on super humble scales and shrinking the entropy density more and more.

180

00:25:28.230 --> 00:25:37.560

Anna Ijjas: And what you don't see is any mess is important that you remember from the simulations and even if you start very far away in terms of metric and energy distribution from value gonna be.

181

00:25:37.920 --> 00:25:44.700

Anna Ijjas: But you get a very smooth and flat universe, no mess that's really important no message emerging on a nonlinear bay.

182

00:25:45.180 --> 00:25:53.490

Anna Ijjas: So that's important because, first of all, so this is a good mechanism for if you just want to say Okay, at the end of this slowly contracting fees, I have a low entropy density.

183

00:25:53.970 --> 00:26:03.390

Anna Ijjas: And I have smooth and flatten the universe, and if I populated quantum fluctuations on top of this, this moving and flattening they would become super humble, and even though.

184

00:26:03.930 --> 00:26:10.920

Anna Ijjas: We don't I I tend to be conservative and then say it is just like an inflation, we have to tune the amplitude and we have to tune their scale.

185

00:26:11.130 --> 00:26:19.740

Anna Ijjas: And we have to be done, they can be described to be consistent with the microwave background and what's really important is, this is an astronomic colloquium.

186

00:26:20.580 --> 00:26:27.360

Anna Ijjas: They don't produce any measurable cancer boats, so this scenario watch out for next five to 10 years if anything gets measured.

187

00:26:27.960 --> 00:26:35.970

Anna Ijjas: This scenario is oh that's right interesting to work on it, because, because we know that it's wrong anyway, so what you want, now, this is the second part.

188

00:26:36.420 --> 00:26:43.080

Anna Ijjas: And this is this is something that that that I talked about next five minutes so it's not enough to to.

189

00:26:43.350 --> 00:26:53.040

Anna Ijjas: Slowly contract and have a smoothing phase there nothing that can be mastered that we are in newtonian physics afraid of that as we will see Tom and was very worried about.

190

00:26:53.670 --> 00:26:57.180

Anna Ijjas: No black was nothing can close to one another, that even though you.

191

00:26:57.840 --> 00:27:06.120

Anna Ijjas: You shrink the entropy density, if you bounce in that everything becomes quantum quantum gravity to quantum bands and what would happen is.

192

00:27:06.360 --> 00:27:17.880

Anna Ijjas: When the blackboards that remains so far, far away from one another and an outside of your hubble patch and store or the entropy outside of your humble patch and you have lost sight of them forever, but again come together.

193

00:27:18.390 --> 00:27:31.890

Anna Ijjas: And you would get but, of course, a crunch and you would have done any everything, so you would have the same problem as big bang cosmology or big bang inflationary cosmology have, how do I get out of quantum faith so that's needs us.

194

00:27:32.280 --> 00:27:39.960

Anna Ijjas: Just from the entropy argument to say, and this is something I have been also working on for a via to stage of trying to make the similar type of.

195

00:27:40.320 --> 00:27:49.020

Anna Ijjas: Food in America and it with the simulations, as we have done for the snow contraction face so that would say you the band's cannot be quantum.

196

00:27:49.860 --> 00:28:00.540

Anna Ijjas: So you have to modify here relativity is our theory of gravity here activities our theory of gravity to our evolution, but we know relativity cannot remain on theory of gravity.

197

00:28:00.990 --> 00:28:08.730

Anna Ijjas: And from from the entropy problem point of view, it might be a suggestion to say, we cannot wait to modify.

198

00:28:09.090 --> 00:28:17.700

Anna Ijjas: Einstein gravity under the plunks can leverage the Planck scale with modifying is no gravity, you might have to do it, one or two orders of magnitude below.

199

00:28:18.030 --> 00:28:34.020

Anna Ijjas: so that we never like facetime vanish into a quantum form quantum gravity face but but bands of the classical scale, so this is a new kind of argument for why to take such idea, serious and I should mention that in the meantime and groups work on this type of ideas.

200

00:28:35.760 --> 00:28:40.560

Anna Ijjas: Rather Brendan burgers group or suchitra agenda and at at at Hopkins and others.

201

00:28:41.220 --> 00:28:48.210

Anna Ijjas: So we just have one example, but certainly with one example, is a good one, and why is it important fabric, for you can be entropy distribution.

202

00:28:48.660 --> 00:28:52.290

Anna Ijjas: Then what happens is you remember with inflation, the problem was.

203

00:28:52.710 --> 00:29:00.300

Anna Ijjas: If you have a scale, you have to explain by all the entropy before reheating before you read the universe to start around the issue dominated era.

204

00:29:00.570 --> 00:29:07.140

Anna Ijjas: would be stored in the scale or slow contraction by smoothing and flattening and suppressing all components of the energy density gives it to you.

205

00:29:07.530 --> 00:29:19.140

Anna Ijjas: So during this era, everything is stored in this killer wheaton entropy density getting slower and slower now You might ask what are you doing with the second law of thermodynamics but what you do with it, is that your total entropy grows.

206

00:29:19.590 --> 00:29:25.980

Anna Ijjas: You just lose sight of it, so the entropy density shrinks by you're sinking in the hubble radio, so what you can see.

207

00:29:26.460 --> 00:29:33.720

Anna Ijjas: The absorber entropy density shrinks but the total entropy cruise then, but after reheating.

208

00:29:34.230 --> 00:29:49.110

Anna Ijjas: Your store everything into the matter radiation sector so, by the way you explained to these bands, also by the gravitational sector is not excited, of course, it has observable consequences if you measure gravitational waves that's out and offer.

209

00:29:50.250 --> 00:30:02.370

Anna Ijjas: And then starting, and this is from observations around redshift 10 the entropy starts to be most of the entropy stored in supermassive black was in form of Pakistan hawking entropy.

210

00:30:02.700 --> 00:30:10.290

Anna Ijjas: And today is like by a huge amount and stored in the entropy, so this is a pretty good story, but Nice, to my mind that wasn't that wasn't there a question.

211

00:30:11.220 --> 00:30:17.880

Anna Ijjas: For the remaining two minutes, I want to address that question because it might be interesting two or three minutes, so it might be three or four months.

212

00:30:18.870 --> 00:30:26.490

Anna Ijjas: That that that Thomas Bingo but isn't such a picture incompatible with the second law of thermodynamics but this one is not.

213

00:30:27.150 --> 00:30:36.150

Anna Ijjas: This one is a single bands, but this is so cool a cyclic universe, and a cyclic universe would ask the question should I stop it's such a model, only five hours on the interested in.

214

00:30:36.600 --> 00:30:47.130

Anna Ijjas: explaining the conditions here and here that's a pretty good start, because I also know that this is fairly insensitive to the initial data on the other hand, you might ask why do I get my scale of field from.

215

00:30:47.640 --> 00:30:57.600

Anna Ijjas: What do I say about this federal stock energy come from again you just cause more just put together something without any relation to what not much relation to observation, except.

216

00:30:57.780 --> 00:31:05.220

Anna Ijjas: You tonight, a little bit for you explain the flatness and smoothness but you don't generically explain what you measure the exact spectrum and.

217

00:31:06.630 --> 00:31:12.270

Anna Ijjas: You have no idea what Doc and I just feel it would be, though, since it's a salient feature for university would be important.

218

00:31:12.540 --> 00:31:22.830

Anna Ijjas: Instead of introducing here an ad hoc scale or maybe you can do something with dark energy and that's why the idea of the site universe content, and this is the wrong kind, this is, this is the one that that.

219

00:31:23.760 --> 00:31:33.150

Anna Ijjas: Sorry, that that Friedman, and porn and critters Friedman introduced and torment criticized, and they criticize exactly and this three grants, namely in this case.

220

00:31:33.570 --> 00:31:38.220

Anna Ijjas: You didn't just make the universe expand and contract and expand and contract.

221

00:31:38.460 --> 00:31:50.820

Anna Ijjas: But you also crunch, that you had a quantum bands and, as I explained the quantum bands obviously to some not just age or the hubble radius was changing periodically which we synchronizes the switch between the contraction and expansion.

222

00:31:51.330 --> 00:31:58.500

Anna Ijjas: But with zero crossing being once the bounce once the going from expansion or contraction but also the scare factor but.

223

00:31:59.010 --> 00:32:04.500

Anna Ijjas: And that led to other problems if you crunch, you lose everything what you want to so contraction.

224

00:32:04.770 --> 00:32:13.170

Anna Ijjas: And how bad, it can be, I just wanted to show you a simulation so you don't have this kalan but people are worried about it, without the scale, I told you watch out because.

225

00:32:13.530 --> 00:32:22.290

Anna Ijjas: That typically run with this pack mess, so a simulation without the scale of field we just met her or beta positive potential would make you really.

226

00:32:22.530 --> 00:32:31.560

Anna Ijjas: look like this, as you approach the balance it's quirky I think mix master behavior just to see this is high school activity behavior without this magical negative potentials killer.

227

00:32:31.890 --> 00:32:39.000

Anna Ijjas: So this is what one can also evade and like you get to next is now, you asked yourself so, and this is what I want to close with.

228

00:32:40.410 --> 00:32:46.800

Anna Ijjas: What do you been from apart from can you perhaps explain more from a psychic universe, be more observation like predictive.

229

00:32:47.220 --> 00:32:54.930

Anna Ijjas: And they also have the entropy problems to solve the how much in a dance like this problem, and I have constraint and more on the exact spectrum of the fluctuations.

230

00:32:55.290 --> 00:33:10.500

Anna Ijjas: than one just follows, so to speak, one so in theory and asked Okay, well, we know what so contraction makes the, and here the physical distance, as I noted by the record and and the hub of patches just the blue called the hubble patch isolates so as I go from one.

231

00:33:11.580 --> 00:33:15.780

Anna Ijjas: side to another, it goes from slow contraction shrinking a lot.

232

00:33:16.350 --> 00:33:25.440

Anna Ijjas: Expanding 64 so first of all 24 the dark energy expansion and shrinking got a hub radius obvious shrinks as much as big as an expense that's periodic.

233

00:33:25.890 --> 00:33:34.830

Anna Ijjas: But what happens is due to the fact that a and physical distance only solely contract and you don't crunch, but transit transit by modifying gravity at the lower.

234

00:33:35.640 --> 00:33:38.280

Anna Ijjas: scared and the Planck scale, but still very high energy scale.

235

00:33:38.550 --> 00:33:47.280

Anna Ijjas: But you read is that nothing crunches black was done merge don't get to one another, but what really happens is physical distance is hardly changed too slow contraction shrink of it.

236

00:33:47.580 --> 00:33:53.160

Anna Ijjas: And then expand a lot we really need to the 60 times, plus dark energy expansion which is again.

237

00:33:53.610 --> 00:34:01.830

Anna Ijjas: Times it's the 10th so then 24th of dark energy expansion and if you continue that way you see that what happens is it's a very different picture.

238

00:34:02.460 --> 00:34:14.280

Anna Ijjas: than the than the torment picture, rather than this is the picture you have an oscillating have radius fair to harbor energy density isolated, the energy scale event and the 10 chapter 10 to the minus 10 to the 10 jab.

239

00:34:14.670 --> 00:34:25.710

Anna Ijjas: For the hubble parameter the distances sharing between the hub was cash by the end of slow contraction is has a radius of Center minus 25 centimeter and as we think at before.

240

00:34:26.280 --> 00:34:32.520

Anna Ijjas: The dark energy phase, and then it moves over to stoke on traction hubble patches huge has a size of a pencil 28 centimeter.

241

00:34:33.150 --> 00:34:37.200

Anna Ijjas: And then I bought what the scare factor, does it shrinks a little.

242

00:34:37.770 --> 00:34:46.830

Anna Ijjas: Experience a lot shrinks a little expands on, and so, if you, and this is, I think, pretty cool result, so if you assume that everything what drives the.

243

00:34:47.160 --> 00:34:59.430

Anna Ijjas: drives drives this the same scale and that the docker engine might not be a cosmological constant, but perhaps a stall evaluate either scale that right now sits in a matter stable minimum or skilled at my quintessence like scale and.

244

00:35:00.120 --> 00:35:09.870

Anna Ijjas: For example, as as as right now pursue those are bye bye swampland configuration by bar fight or it has stolen, it was out of that Facebook would mean is the same scale that.

245

00:35:10.140 --> 00:35:20.760

Anna Ijjas: My drive or dark energy evolution can drive us from expansion contraction and from contraction to store contraction and from slow contraction to a gentle bands too.

246

00:35:22.170 --> 00:35:33.390

Anna Ijjas: Hot expansion and if you asked Palace look like, on average, because no Cosmo just can't live without the sitter they often say that may be dark energy is a hint that.

247

00:35:33.960 --> 00:35:40.500

Anna Ijjas: The early universe went to a dissenter like phase, and I would say, maybe a dark energy, together with the entropy problem.

248

00:35:41.400 --> 00:35:52.020

Anna Ijjas: Is a hint and the lack of yet measured primordial gravitational waves is a hint that the evolution is cyclic but, on average, it looks like a decider like phase.

249

00:35:52.410 --> 00:36:05.760

Anna Ijjas: it's it's it's effective the sitter hubble parameter given by a dark energy density and what really happens is it's an average distance I like don't ever be deceptive, and this is what I closed, and I look forward to your questions, thank you.

250

00:36:11.790 --> 00:36:12.660

Morgan Elowe MacLeod: Thank you so much.

251

00:36:13.980 --> 00:36:18.060

Morgan Elowe MacLeod: Okay, so everyone feel free to send me your questions.

252

00:36:18.600 --> 00:36:19.440

Anna Ijjas: or just asked me.

253

00:36:20.160 --> 00:36:23.760

Morgan Elowe MacLeod: or go ahead and speak up, you can raise your hand if you wish.