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COSMOLOGY

Is the dark energy a gigantic error?

The universe is falling apart faster and faster. That's the common theory. Now a physicist from Oxford wants to have refuted this. If he were right, the consequences would be enormous.

by Robert Gast

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Recently Subir Sarkar sent an e-mail to selected colleagues around the world. "Most important to me was that she also reached Jim Peebles," says Sarkar. He is a physics professor at venerable Oxford University, but Jim Peebles is one step higher: In October 2019, the American was awarded one half of this year's Nobel Prize in Physics .

Peebles is one of the architects of the theory building, with which scientists describe the universe. According to this standard cosmological model, space arose 13.8 billion years ago and has been expanding ever since. The cosmos does not lose momentum, but it expands faster and faster with time. Responsible is the ominous dark energy; a kind of ubiquitous antigravity that is supposed to be everywhere in the Universe and makes it bigger and bigger.

Objection of a lateral thinker

Subir Sarkar does not think much of this theory. The Indian-born researcher is considered an excellent physicist - and an uncomfortable lateral thinker. Already long the 66-year-old passes on the data from which astrophysicists infer the accelerated expansion. Again and again he has filed doubts, now he wants to have achieved the decisive proof together with three younger colleagues. "There's acceleration, but it just pulls us in one direction," says Sarkar. "What we observe can not be the dark energy, because it has to work in all directions."

Supernova 1994D | In 1994, a bright spot appeared at the edge of the 55 million light years distant galaxy NGC 4526 (bottom left): a type 1a supernova. The starbursts are used by researchers as "standard candles," as they always emit the same amount of light and thus reveal their distance to us.

If that were true, the consequences would be enormous: according to the cosmological standard model, dark energy is the dominant component of our universe, accounting for 68 percent of the energy-mass household. It would be much more common than dark matter (27 percent) and ordinary matter (5 percent), which is made up of stars, planets, and humans. The Stockholm Nobel Committee is also likely to be threatened: in 2011, it awarded Saul Perlmutter, Brian Schmidt and Adam Riess three of the discoveries of accelerated expansion.

Was that a hasty decision? Most experts do not think so. They point to the many indicators that have been supporting the existence of dark energy for 20 years. Sarkar primarily attacks one of these lines of reasoning. It is based on a special form of starburst, which helped the teams around Perlmutter and Schmidt in the late 1990s, the accelerated universe from the baptism had lifted.

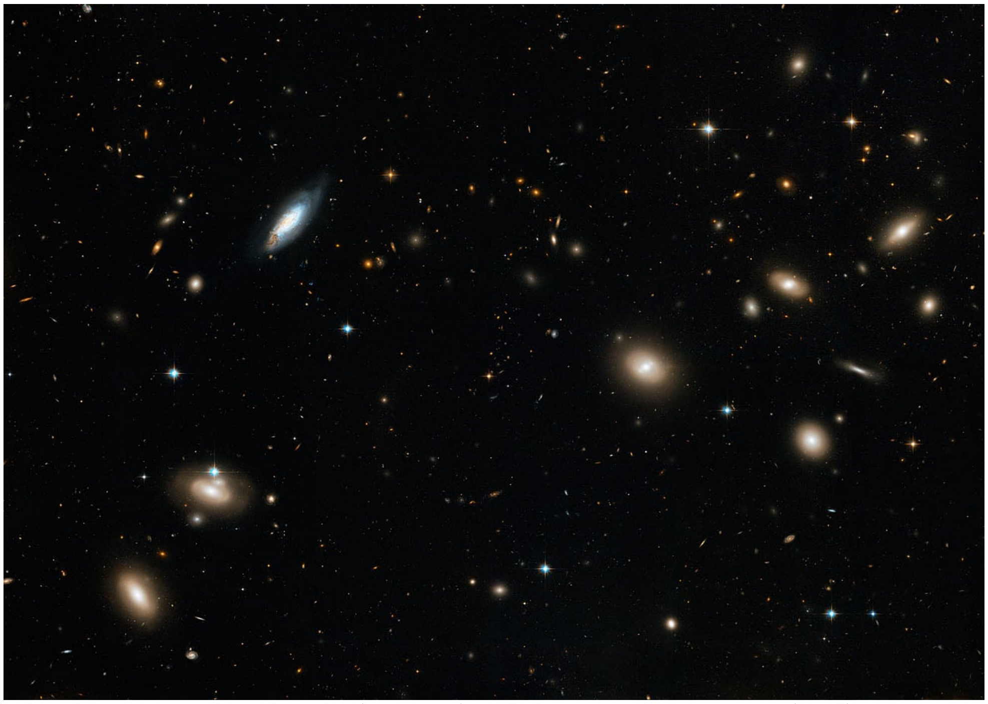
> "The cosmos does not seem to be isotropic, so we are not Copernican observers"
>
> (Subir Sarkar, Oxford University)

These type 1a supernovae release about the same amount of energy and radiation each time. If you observe one of them in a distant galaxy and measure over several days how bright the supernova appears on Earth, the distance can be estimated. Perlmutter, Schmidt, and Riess had recorded dozens of such events, some billions of light-years away. For each of them, they also determined the "redshift." It reveals how much the radiation was stretched on its long journey through space as a result of the cosmic expansion. Comparing this with the distance to the source, one can estimate the extent to which space has grown during the journey.

Fast, faster, universe

The later Nobel laureates had actually expected to observe a decelerating universe, since the momentum from the Big Bang would have to weaken over time because of the attracting masses. To their surprise, however, the collected data could only be conclusively explained when the universe is gaining momentum. To date, experts stick to this finding; Meanwhile, they rely on more than 1000 observed supernovae.

But among professionals makes a certain discomfort the round for a long time . Many results of cosmology are based on the Copernican principle. Physicists mean by this the assumption that the universe is isotropic, so no direction prefers. Looking at the night sky in the southern hemisphere, the galaxies visible there should in principle behave in the same way as cosmic objects on the northern firmament. Also, the matter should be approximately evenly distributed in space, at least when considering the largest structures in space.



Deep-field image of Hubble | Clusters of galaxies, such as the Coma cluster, recorded here by the Hubble Space Telescope, form the building blocks of the largest structures in the Universe. The coma cluster is more than 300 million light-years away from us, contains about 1000 large galaxies and is itself part of an even larger structure, the Coma super heap, which no longer belongs to Laniakea.

But can humanity say with certainty that both are the case? It is certain that our Milky Way, together with its neighbors, moves swiftly through space. This can be seen, for example, in the "cosmic microwave background," a kind of afterglow of the Big Bang that can be measured at any point in the sky. The radiation appears on one half of the firmament to be about one hundredth more energetic than in the opposite direction. The effect can be explained if our galaxy group moves at 620 kilometers per second relative to an observer, who would perceive the background radiation completely isotropically.

This "self-motion" is a problem if you want to determine the cosmic expansion speed based on the redshift. Because not only the dark energy can prolong light waves by making the space between the world islands bigger and bigger. The motion of a galaxy drawn in our direction by the gravitational force of its cosmic neighbors can also stretch the wavelength - just as the school physics Doppler effect for the sound waves of an ambulance suggests.

Beyond 500 million light years

But how much of the measured redshift comes from cosmic expansion, how much of the self-motion of source and observer? For cosmologists this is a tricky question. They therefore try to estimate as much as possible the motion of galaxies as a result of ordinary gravity. They then use the result to correct the redshift of distant supernovae. Ideally, then only the portion remains, which goes back to the expansion.

These corrections have long been a standard method of modern cosmology. However, from the point of view of Subir Sarkar, his colleagues are making it a lot easier: "People are correcting the data on the basis of inadmissible assumptions," he says. "In the end, then, what they were looking for came out."

In an article recently published in the journal "Astronomy & Astrophysics," the Oxford theorist puts his argument in more detail: cosmologists usually assume that the intrinsic motion of our galaxy group is no longer significant when we look at distances overlooked by more than 500 million light years. On these scales, the current in which the Milky Way moves should be superimposed by much more powerful matter movements and conform to the "reference system" of cosmic background radiation, so the widespread assumption.

Incorrect corrections?

But, is this really the truth? Or does the flow of matter that moves our Milky Way perhaps go much farther into space than we thought it might not even be like the microwave background? Is our entire visible universe possibly dominated by powerful currents that make universally valid statements very difficult? Sarkar is convinced of this scenario: "The cosmos does not seem to be isotropic, so we are not Copernican observers," he says. Accordingly, the redshift corrections for very distant supernovae are faulty.

Sarkar and his team have therefore started a re-analysis of publicly available supernova measurements. "It was not that easy to find this data because almost all the records were already fiddling," he complains. Finally, the four researchers found in a 2014 collection containing 740 starburst explosions and reversed their redshift corrections.

> "To say that there is no dark energy, in the face of many other data is simply adventurous"
>
> (Matthias Bartelmann, University of Heidelberg)

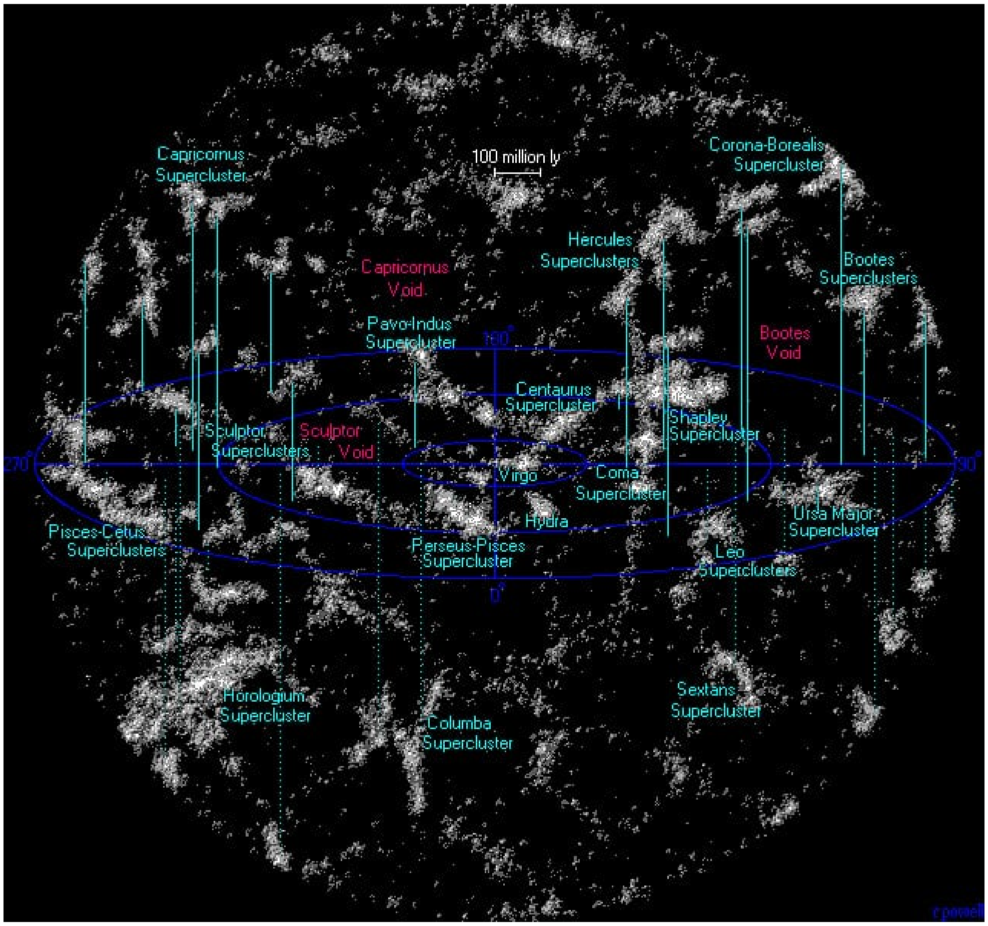
Subsequently, his team wants to have an unbiased review of which model best fits the data. The researchers also allowed for a parameter that expresses a directional dependence of the redshift, as one would expect as a result of a significant relative movement of source and observer. Models with such a "dipole component" performed significantly better than those in which the redshift has no directional preference, according to Sarkar.

The accelerated expansion would be on the edge, the researchers continue: What cosmologists have as yet attributed to the dark energy, is primarily the acceleration of our own galaxy group. "I suspect we're being attracted by some great mass beyond the 650 million light-years distant Shapley galaxy cluster," says Sarkar.

Criticism from America

Can this be? Is the dark energy a gigantic mistake? Or did Sarkar himself make a mistake and interpret data unilaterally? Anyone who speaks to other astrophysicists always hears the latter conjecture. In particular, US scientists respond with fierce rejection to the thesis of the professor from Oxford. "Extraordinary claims require extraordinary evidence," says Dragan Huterer of the University of Michigan. "I do not see them here in any way."

Huterer and several of his colleagues find that the publication of Sarkar basically contradicts itself: A table in the appendix lists how well the conventional, dipole-free model explains the analyzed supernova data. "If you compare that with the model of the authors from another table in the paper, you see that it fits much worse to the data," says Huterer.



Galaxy heap everywhere | The Milky Way and its neighbors (the "local group") are part of the Virgo galaxy cluster in the center of the map. It shows the distribution of galaxy clusters up to a billion light-years away. There are about 63 million galaxies in this volume.

Sarkar, however, denies that it's easy to compare the entries in the tables in his paper - and points to a different statistical view that suggests his model performs better. But why does that not emerge from the paper? It was a mistake not to make clear in the publication, he justifies himself. That would have changed little: "Then those who do not like our conclusion would have just found another stick to attack us."

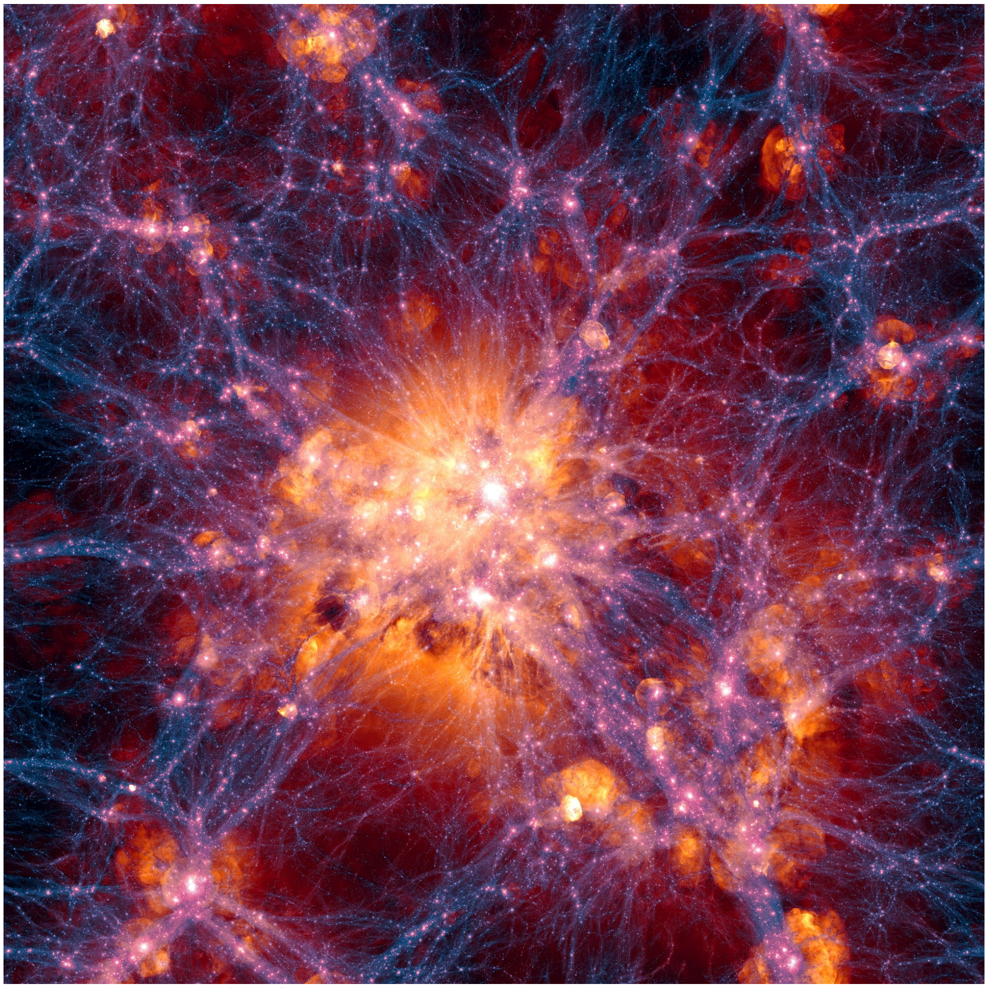
Sarkar may be said to include David Rubin from the University of Hawaii, who has earned his doctorate with Saul Perlmutter. Rubin has to gather together with a student several criticisms and on the preprint server arXiv published . Three years ago, Rubin had crossed the blades with Sarkar , as he had once criticized the analysis of supernova data.

One of the criticisms is aimed at the supernova catalog that Sarkar's team used for its re-analysis. This "Joint Light Curve Analysis" dates back to 2014, although there are now newer and larger datasets. Why did not Sarkar use these? An answer to this can be found, inter alia, in a response that he and his team also published on Wednesday on Arxiv. "These data do not seem to be publicly available in a form that we can use," it says cryptically. In addition, in the previous paper of the group there was talk of "concerns about the accuracy of the data" that now seem to have disappeared.

In the shadow of the Nobel Prize winners

Because of such details, one can understand the reluctance with which many astrophysicists encounter Sarkar: he is sometimes preceded by the reputation of relying primarily on the data that supports his argument. But is the scathing criticism from the United States really justified? Or perhaps the researchers there react so allergically because the Oxford theorist questions the life work of Perlmutter, Schmidt and Riess - who are still very influential figures in the US cosmological scene?

In fact, European experts are arguing more ambiguously when asked about Sarkar's recent move. There is, for example, Bruno Leibundgut. The Swiss was one of the US teams that discovered the accelerated expansion in the late 1990s, and later became Science Director of the European Southern Observatory ESO. Looking at Sarkar's paper, he says, "I think those are questions that you can ask." In detail, however, the thesis of his Oxford colleague does not convince him - among other things he misses a thorough discussion of the uncertainties of the analyzes.



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The Cosmic Network | This detailed simulation of the large-scale structures in the universe was created in the framework of the Illustris simulation. The distribution of dark matter is blue and that of the gas is orange. The pictured area has an edge length of 300 million light years. Clearly visible are the filamentous accumulations of matter.

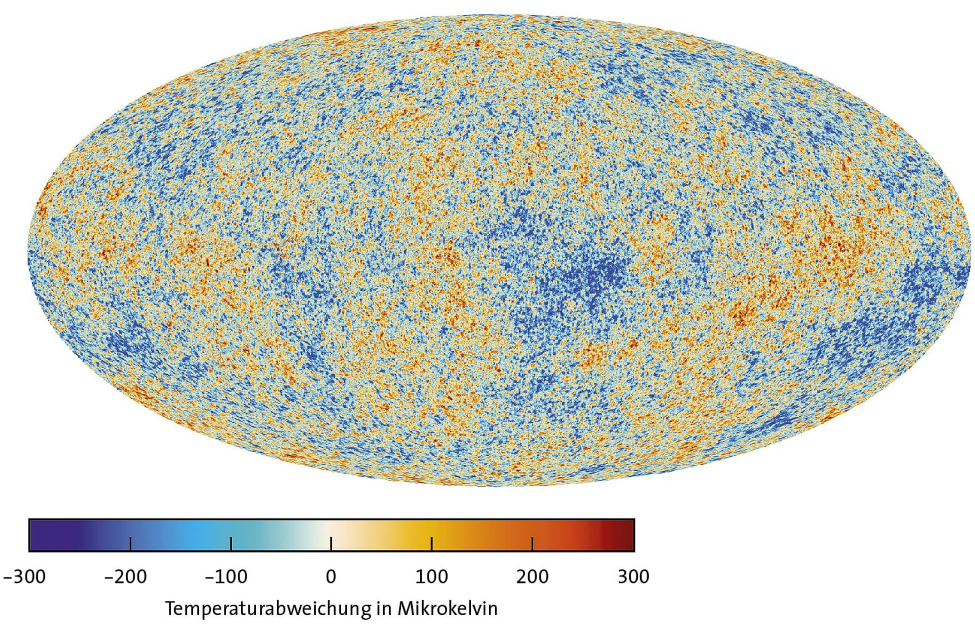
In general, one must distinguish two statements of the publication, Leibundgut finds: First, there is the question of whether the direction of the red shift must be considered more than before. "So far we can not rule out that there is a dipole here," he says. The other question is whether one can conclude that there is no dark energy. "I do not think that's what the data is."

Meaning, the dark energy is there, but cosmologists underestimate the statistical uncertainties in their analyzes. The same is true of Dominik J. Schwarz of the University of Bielefeld. He considers Sarkar's push for an important contribution: "I think it is absolutely right not to correct the supernova data before adapting a model, but to view these corrections as part of the model - not as part of the data," says Schwarz , The latter is standard in many cosmology analyzes, but could falsify the results in the worst case. He therefore search for similar questions.

Matthias Bartelmann from the University of Heidelberg can also find something positive in the core of the work. "It takes up the important point that there may still be unresolved dependencies in the supernova data that reduce the significance of the results derived from it." But the conclusion drawn from this goes far too far for Bartelmann: "On the basis of this finding alone, there is no dark energy, and in view of many other data, it is simply adventurous, "he says.

Not only supernovae point towards darker energy

There is, for example, the cosmic background radiation from which researchers can read not only the speed of our Milky Way, but also the matter distribution 380 000 years after the Big Bang. Indirectly, it can be concluded that there must be large amounts of an unknown form of energy.



Background radiation | From 2009 to 2013, the ESA spacecraft Planck measured the cosmic background radiation of the entire sky with the best accuracy and angular resolution so far. The spectrum and intensity of the radiation correspond at each point of the sky to a certain temperature, which is shown in color coded here. The temperature range, which is shown in the picture from deep blue to deep red, corresponds to only a few millionths of the average temperature of around 3 Kelvin.

Also, the distribution of galaxy clusters in the universe today speaks for many of the dark energy experts: the cosmic structures look like the density fluctuations seen from the background radiation, accelerated expansion in the last 13.8 billion years were greatly enlarged. In addition, so-called gravitational lenses and the number of galaxy clusters at certain redshifts for dark energy, says Dragan Huterer.

For Subir Sarkar these are all arguments, which could have a different explanation. Anyone who talks to him about criticizing his work experiences a polite man, who, however, leaves little doubt about his thesis. He has a comprehensive, emphatically presented answer to every technical objection. He always sounds as if this answer completely invalidates the objection. "People are often just too lazy to understand my analysis," he complains.

Whether Jim Peebles will take the time? Sarkar had informed the newly crowned Nobel laureate by e-mail about his new paper. Peebles also responded, on December 3, Sarkar says: He is just on the way to the awards ceremony in Stockholm and want to look at the essay in the plane. So far, the US colleague unfortunately not back - no wonder in the many festivities around the Nobel Prize gala. But the answer will surely come: "Jim has always been open to our criticism."

Robert guest
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