Translated Version

Physics/Astronomy/Astrophysics

New possible link between different energy scales in the context of gravity

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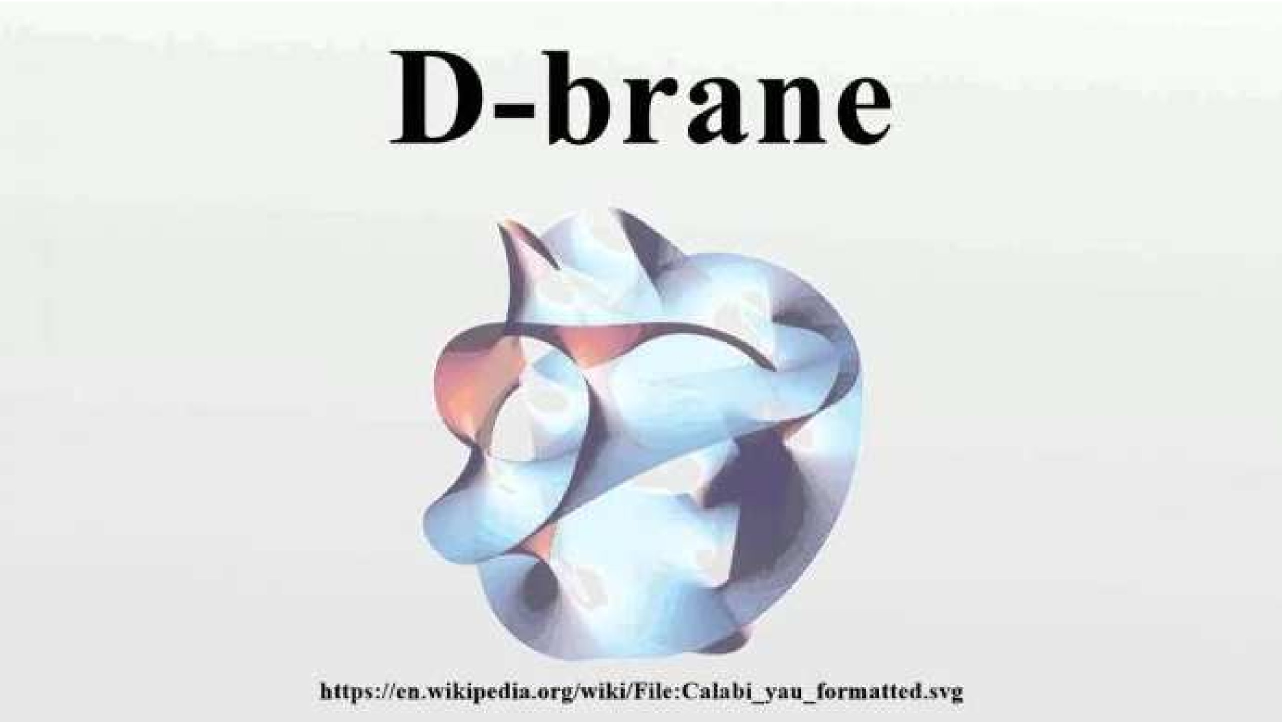

New possible link between different energy scales in gravity

A new work just published in [*Int. J. Geom. Meth. Mod. Phys. Vol. 18, No. 14 (December 2021)*], entitled *"A topological approach for emerging D-Branes and its implications for gravity"*, continues the search for *emerging spaces* in the cosmological field.

A team of researchers, made up of three mathematicians and two theoretical physicists, has introduced and applied a model based on particular geometric manifolds, the so-called *PNDP-manifolds*, to gravitation, in a completely new way, in the context of the *emergent brane-world.*

"The PNDP-manifolds", as **Alexander Pigazzini**, a member of the research team and mathematician for the Danish company *Mathematical and Physical Science Foundation* explains, *"are very particular Einstein warped product manifolds that we have introduced, which also gives an interpretation to the concept of "virtual dimension". These are "objects" that are shown to possess a certain dimension only if a certain algebra defined on them is taken into consideration, hence the term "virtual", to indicate that the independent parameters involved in defining physical or conceptual complexity are not necessarily only those that are apparent. "*

"Years ago" - continues Pigazzini - *"the then Harvard professor, Arkani-Hamed, now professor at the Institute for Advanced Study in Princeton (IAS), produced a series of works in which he considered that space was not a fundamental property of dimensions. He argued that space was instead a secondary property created by more fundamental entities and in this sense the dimensions could also vanish ".*

The new geometric /topological approach to *emerging spaces*, introduced by the team, is based precisely on an interpretation of this background, i.e. in considering that the dimensions, deprive of space, vanish. It is therefore necessary to define particular fundamental objects conceived as if some of their dimensions could interact by "canceling themselves out" virtually (i.e., from a perceptual point of view).

The article, therefore, starts from the assumption that, at a fundamental level, a D-brane can be formed by "objects" (*PNDP-manifolds*) that emerge point-like, that is with zero virtual dimension, and that "interact" together.

The working hypothesis continues by considering the *PNDP-manifolds* endowed with an arbitrary orientability, that is, as the team members, **Saeid Jafari** and **Cenap Özel** (mathematicians at the *Mathematical and Physical Science Foundation* and the *College of Vestsjaelland South*, the first , *and King Abdulaziz University*, the second), report: *"We thought that inside a PNDP-manifold, the underlying surface of the virtual point-like manifold, can be configured as a Möbius strip or else as an orientable surface and therefore, at a fundamental level, we could obtain these "bricks" with one of these two configurations in a completely arbitrary way."*

Richard Pincak and **Andrew DeBenedictis** (theoretical physicists; the first at the *Institute of Experimental Physics of the Slovak Academy of Sciences*, and the second at *The Pacific Institute for the Mathematical Sciences* and the *Department of Physics of Simon Fraser Un*iversity in Canada), go on to underline that *"at this point, the further step was to propose that the gravitational interaction can derive, as a natural mechanism, from non-orientability and therefore advance considerations regarding gravity as if it were a topological characteristic (which we call a "defect") already intrinsic in the spatial fabric of the brane (at high energies)".*

By introducing some appropriate hypotheses on dimensional interactions, the analysis carried out in the article continues showing a possible link (at lower energies) between this "defect" and the perceived curvature of space.

"In other words, from the hypotheses considered" - resumes Pigazzini - *"we identify these topological defects (non-orientability) with gravitational interactions. In practice, through a mechanism triggered by these hypotheses, we obtain an effect known in mathematics as a "parallelism defect" to which we associate the appearance of an effective curvature on low-energy scales (macroscopic level). "*

The entirely geometric / topological approach, in which everything arises from *fundamental spatial dimensions*, aims to propose a new possible link between different energy scales in the context of gravity.

"What is certain is that, as with many other speculative theories, we are still far from being able to carry out experimental tests" - adds DeBenedictis, who reports that - *"a possible experimental verification could be related to the fact that at a sufficiently high energy, we might be able to detect that the tilt, in a vector quantity, will vary in a discrete rather than a continuous way. They appear continuous only on a macroscopic scale, because each PNDP tilts the vectors by a small amount and many small tilts (while a vector is being transported), will appear as a continuous change even if it is not ".*

"A macroscopic observer, in fact" - Jafari resumes - *"can only "see" at a resolution that, in current experiments, is on the Tev scale, which corresponds approximately to 10^(- 19) meters, but we expect that the PNDP scale is much higher than this, perhaps in the order of the Planck scale, so any experiment done with current technology would include a very large number of PNDPs making us unable to observe the discrete phenomenon ".*

"A vector quantity could be any physical quantity that has a vector representation. It is well known that particles of motion with spin in a gravitational field are slightly different from the motion of a particle without spin " - Özel and Pigazzini report - *"discrete gravitational effects would affect both these types of motion, so probably if we could make sufficiently precise spin measurements on particles as they propagate in a gravitational field, we could also detect if the nature of gravity is really as discrete as we assume."*

"One possibility", adds Pincak, *"could relate to the anomalous dispersion of cosmic rays or, better still, gamma-ray bursts: the greater the energy of a particle (the shorter its wavelength), the greater the probability that it is sensitive to this microscopic discrete displacement, which we would have at a fundamental level by some PNDPs."*

"Theories with discrete gravitational effects tend to predict that the propagation of different wavelengths is slightly different" - continues Pincak - *"due to the fact that higher energies are more sensitive to the underlying microscopic structure than the wavelengths at lower energy".*

"Since the energy scales of the microscopic realm are so high, it is believed that currently the only possibility of measuring such a discrete effect could be with gamma-ray bursts that come from very distant galaxies, that is, the effect is tiny, but is accumulated (integrated) as high-energy particles travel vast distances, so that eventually the cumulative effect may become measurable, although probably still too small."

"Almost any experiments that are sensitive enough to distinguish small discrete (versus continuous) shifts of vector quantities in systems of particles propagating freely in a gravitational field would in principle be a potential candidate for experimental tests. But it would still be difficult because the amount of discrete "jump" would be very small", concludes DeBenedictis.