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CORRESPONDENCE

'To the Editors of 'The Observatory'

An Old Idea

In a recent review[1], Heavens noted that "the notion of the de Sitter spacetime as due to a fluid was not considered reasonable in 1973 since the pressure would be negative." Interestingly, that idea was first proposed by Erwin Schrödinger[2], just a few months after Einstein's first paper[3] on relativistic cosmology; Schrödinger noted "that the completely analogous system of solutions already exists for the field equations in their original form — without the terms [corresponding to the cosmological constant] introduced by Mr. Einstein [citation corresponding to my ref. 3]. The difference is superficially very small: The potentials remain unchanged, only the energy tensor of matter gets another form." [my translation]. Such a fluid has "a constant density and constant, spatially isotropic inner tension". I wonder if such a fluid would have been considered acceptable earlier if it was described as being under tension rather than having negative pressure.

Einstein[4] replied that he had considered it as "the most obvious possibility when writing my paper", but that it was "not worth a mention". He considered two possibilities, first that the (negative) pressure of the fluid is a universal constant and second that it is not. He dismissed the first case since it amounts to replacing p with Λ and moving it to the left-hand side of the field equation and assumed that that couldn't have been what Schrödinger had meant. I don't know if that is what Schrödinger meant, but it is what is usually thought of as 'dark energy' today (though, depending on the definition, dark energy could have an equation of state other than $p = -\rho$, possibly depending on time as well). As the second possibility entails "not only the hypothesis of the existence of a non-observable negative material density in interstellar space but also a hypothetical law for the space-time distribution of this matter density", Einstein saw it as not viable since it led "too deeply into the thicket of hypotheses".

Although Schrödinger was a polymath (*e.g.*, he was an expert on human colour vision), his interest in General Relativity was not a fluke; in his later years, like Einstein he distanced himself from quantum theory (his famous cat thought experiment intending to demonstrate the absurdity of the Copenhagen interpretation, which became the leading interpretation of quantum mechanics) and, again like Einstein, pursued classical unified field theories (also, like Einstein, with little if any real success).[5]

Even though a fluid with $p = -\rho$ has the same effect as the cosmological constant, the two are not the same, and, as far as we know, both could exist. That possibility was famously invoked by Weinberg[6] to explain the observed value of the cosmological constant, which is much smaller than expected by many on the basis of arguments from quantum field theory: the expected huge value (corresponding to a fluid) exists, but is *almost* cancelled by a 'bare' *negative* cosmological constant, the fortuitous cancellation being explained by the weak Anthropic Principle. There is a tendency to interpret the cosmological constant as a negative-pressure fluid, not because of an equation of state different from $p = -\rho$ (with which all observations are compatible), but because of the hope to understand why it exists, why it has the value it has, what the physical mechanism behind it is, and so on. However, the Einstein field equation has two physical constants, Λ and G. Similar questions could be asked about the latter as well (why is it non-zero, why is gravitation much weaker than other forces, what is the 'mechanism' behind it), but rarely are.

Yours faithfully,
Phillip Helbig

Thomas-Mann-Straße 9
D-63477 Maintal
Germany

helbig@astro.multivax.de

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