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# Van der Waals anomaly: an analogue of dark energy with ultracold atoms

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It has been conjectured [1-3[ that the dark energy described by the cosmological constant is a manifestation of vacuum fluctuations. Here we show that an analogue of such dark energy can be observed with ultracold atoms.

This “dark energy” appears as an additional pressure in the Maxwell stress tensor of vacuum fluctuations in dielectric media. Maxwell’s equations of stationary fields imply that the stress is given by the gradient of the permittivity divided by the permittivity and multiplied by the trace of the electric part of the stress, plus the equivalent expression for the magnetic stress (if the permeability varies).

However, for vacuum fluctuations an anomaly emerges: a pressure needs to be added to the stress that depends on the dielectric functions and their derivatives up to second order. This pressure corresponds to the trace anomaly of quantum fields [4] and it affects the momentum balance in the dielectric like a cosmological constant would in space. It is caused by the violation of reciprocity in the renormalization of the vacuum stress.

Bose-Einstein condensates of alkali atoms [5] are dilute quantum gases with simple atom-atom interactions that can be controlled by Feshbach resonances [5]. As they are dilute dielectric media the vacuum force in such condensates is entirely given by the anomaly. We predict that the anomaly changes the excitation spectrum of a condensate in an optical trap. The effect is small but it can be probed near the limit of vanishing scattering length.

An experimental demonstration would test, for the first time, the idea of trace anomalies caused by the nonreciprocity of renormalization. It would also be a crucial test for vacuum forces inside nonuniform media [6] where little is known and tested empirically (in contrast to vacuum forces between dielectric bodies). Finally, by the power of analogy between curved space-time and media, it might shed some light on dark matter.

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