Hunting for Chameleons, a Possible Candidate for Dark Energy

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2017

Summary

The universe is experiencing an accelerated expansion, which can not be explained by General Relativity (GR). According to GR the expansion of the universe should slow down. One way to solve this problem is to have a scalar field that will explain the expansion without the need for an alternative theory to GR. There have been many scalar fields hypotheses that offered a solution. However, most of their parameter space have been excluded by terrestrial experiments. In 2004, Khoury and Weltman [11] proposed a scalar field, named *the Chameleon field*, with a screening mechanism. The name of the theory comes from the idea that this peculiar field can adapt to its surrounding. Therefore, this field can answer for this problem, without facing the stringent experimental limit that other scalar fields, without screening mechanism, have faced.

In 2010, a novel approach to testing the Chameleon theory was proposed [30]. The idea is to place two plates parallel, with a large interaction area, at a few tens of μm immersed in inert gas. By varying the pressure of inert gas, the Chameleon interaction between two plates are expected to change. Therefore, if other microscale interactions are accounted for, one can have a possibility to test the Chameleon theory. Following this idea, we designed an experiment using a custom made actuator (force sensor) facing an ultra flat surface. The relative displacement of the force sensor monitored by a high precision capacitance bridge to 7th digit at a nominal capacitance of 100 pF. Since measurement was done in DC, we designed an isolation system to reduce disturbances that can couple to the sensor in frequencies below 10 Hz.

Our work over the past five years offered a robust force sensor with a resonance frequency of 15.9 Hz and spring Constant of 0.63 N, and a passive anti-vibration stage with 60 dB damping at 10 Hz. However, there have also been setbacks that allowed us to find a flaw in the design or in the implementation, such as long-term stability of the detection system, and unnecessary complexity of the detection system due to the choice of capacitive bridge detection. Replacing the detection system with an optical readout and reducing the long-term drift of the plate separation are among further steps to take before testing the Chameleon theory.