Dark energy in the laboratory

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Since in 1998 it was discovered that our universe expands at an accelerated rate, dark energy has evolved from a niche subject of cosmology to a focus topic of many related fields. Several theories have been devised to unravel the mystery of what the physical mechanisms behind dark energy could be, some of which yield testable predictions. Over the past decade, finally, numerous experiments were realized with the aim to tighten the present limits on the free parameters of these theories. The possible coupling of hypothetical scalar particles to photons has been tested in the GAMMEV/CHASE afterglow experiments and in CAST at CERN. More general interactions have been probed recently by oscillations of a Rb-Bose-Einstein condensate, neutron interferometry, bouncing neutrons, micro-spheres, Casimir measurements, and interferometry with Cs atoms, the latter giving the presently tightest bounds on parameters of some hypothetical theories. Many more ground and space based experiments are under construction and will be operational soon, giving hope to finally exclude some theories or find evidence for the actual mechanisms behind dark energy. However, we are not there yet. The dark energy in the laboratory workshop aims to reconcile the present status of experimental evidence regarding dark energy, discuss resulting limits on various theoretical approaches, and spur new ideas to explain the accelerated expansion of our universe.

One of the most important goals of the workshop was to bring together researchers from similar but distinct fields in order to learn from each other, foster new relations and collaborations. This goal was entirely fulfilled, as already during the workshop experimentalists began reinterpreting their data in the light of various theoretical models they became aware of. Similarly, the numerous moderated and non-moderated discussions have led to a common ground of understanding of the theoretical side of dark energy models, both the modified gravity approach and screened scalar interactions. The consensus is that most models are actually either ruled out already as a realistic explanation for dark energy or will be tested exhaustively very soon. Numerous ideas have been brought up on how to move on and what else to try to explain the observed accelerated expansion of the universe. However, significant theoretical work will be necessary to evaluate these approaches thoroughly. Presently, there seems to exist no single candidate theory to explain the observed effects in a fundamental and satisfactory way.
For the community of dark energy physics, this workshop has certainly enabled a consolidation of recent efforts, a re-orientation, and an indication of what to try and what not to try to push forward the quest for a solution to the dark energy conundrum. However, despite the general motivation and high spirit, the present phase of scientific progress is a difficult one. Thus, being all on the same page now, the community can move forward and focus on new approaches. A new cycle of developments can be started.
Another goal of the workshop was to find a common ground in organizing meetings and scientific visits more frequently. While the proposal to apply for a COST action grant was refuted with the reasoning that the community is too small to find the required amount of participating groups (altogether, 15 nations need to be represented during the initial phase, an 26 for the complete network). A few alternatives have been discussed on how to organize workshops similar to the present one on a yearly basis. A committee to lead this action has been formed, comprising of Anne Davis, Clare Burrage, Babette Döbrich, and Ricardo Decca, who took the lead in preparing an application for a workshop at the Gutenberg University Mainz, which offers a similar infrastructure than the Lorenz center.

A point that became clear to me during the workshop was that researchers from related fields often face similar challenges without noticing that their peers may have an applicable solution. Bringing together people from such fields results in synergy effects and new ideas. This effect applies to both experimentalists and theoreticians and is highly appreciated.

I have heard from others and experienced myself several times that the general way in which Lorentz workshops are organized, with a rather loose program, ample time for breaks and discussions, and the spacious offices and facilities motivates people to immediately get to work with their new ideas, and to discuss problems in more detail and privacy than would be possible on a regular conference. In this sense, It seems that Lorentz workshops can potentially generate breakthroughs and have a large added value for a community, as such an intense interaction would not be possible in a different setting.

While for the dark energy community, no immediate breakthrough has been achieved, the resume is clearly positive in the sense that a common consensus could be formed on the status of theoretical work, and new scientific relations that may lead to future collaboration were formed. The community has grown and is synchronized and organized now, ready to implement and test new ideas regarding dark energy – thanks to the Lorentz workshop.

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