Modified gravity v. dark energy

April 12 2007, By Miranda Marquit

For many years now, scientists have wondered why the universe is expanding faster than it should be. Through conventional knowledge of physics, the universe should be expanding at a slower pace that observations show that it is. “There are two main theories for why the universe is expanding so fast,” Martin Kunz tells *PhysOrg.com*. “One is modified gravity and the other is the presence of dark energy. We want to figure out how to distinguish between the two.”

Detecting the difference between dark energy and modified gravity would provide physicists with a better understanding of how the universe works. And detecting modified gravity would add a further benefit by contributing to the understanding of one the fundamental forces in the universe.

Kunz, a scientist at the University of Geneva, and his colleague Domenico Sapone have published a Letter in *Physical Review Letters* addressing the difficulties of distinguishing between modified gravity and dark energy. The Letter is titled “Dark Energy versus Modified Gravity.”

“There are theoretical problems with dark energy,” explains Kunz, “and this had led people to modified Einstein’s general relativity in order to get modified gravity, which some think would explain the expansion of the universe.” The problem, he says, comes in when one tries to observe one of these phenomena. “We cannot observe either dark energy or modified gravity directly. We can only observe how galaxies behave.”

Kunz points out that in many models, the universe is shown as smooth, assuming that the energy is evenly distributed and homogenous. “This is not completely the case,” Kunz says. “There are small fluctuations. But many measurements only probe the smooth universe.” He continues: “In this simple model, you can make everything look like a component with negative pressure, there is no way to decide whether it is due to dark energy or a modification of gravity.”

Some scientists have looked at the growth of structure in the universe as way to distinguish between the effects of modified gravity and the effects of dark energy. It is these measurements that Kunz and Sapone find lacking in terms of ability to detect differences between the two. Through some modeling and equations of their own, the two have found that dark energy perturbations can affect the distribution of galaxies in a way that matches the effects of modified gravity. “At a certain level, dark energy and modified gravity look the same,” Kunz explains.

“People hoped that you could prove general relativity wrong by studying how structure forms in the universe,” Kunz says. “We showed that you could rule out certain models of dark energy, but not general relativity itself.”

So, while Kunz and Sapone did not manage to show how to distinguish dark energy from modified gravity, they did discover new avenues that need to be explored in the debate of modified gravity versus dark energy. And they discovered something else: “One thing we saw that was really essential was anisotropic stress,” says Kunz. “The presence or absence of anisotropic stress might help to distinguish between the two. If we measure the presence of anisotropic stress in the universe, it is more likely to be modified gravity.”

Kunz also sees hope for the future of settling this debate. “Over the next few years, precise measurements of weak gravitational lensing will become possible, which also measures anisotropic stress. Combined with the next round of distance measurements with supernovae, we will be able to get good constraints."