Gravity might amplify quantum fluctuations, create astrophysical objects

May 17 2010, by Lisa Zyga

(PhysOrg.com) -- In a new study, physicists have proposed that gravity could trigger a runaway effect in quantum fluctuations, causing them to grow so large that the quantum field's vacuum energy density could dominate its classical energy density. This vacuum-dominance effect, which emerges under some specific but reasonable conditions, contrasts with the widely held belief that the influence of gravity on quantum phenomena should be small and subdominant.

Daniel Vanzella and William Lima of the University of São Paulo in Brazil have suggested the new idea in a study published in a recent issue of Physical Review Letters.

The concept is based on the idea that virtual particles are continually popping into and out of existence in empty space. Vanzella and Lima propose that a powerful gravitational field - such as one that exists near a neutron star - could create a region of many virtual particles densely packed together. The energy density of the virtual particles might grow to become even larger than the energy of the neutron star, or other object that generated the gravitational field.

At this size, the vacuum energy of the quantum field could possibly influence astrophysical processes. For example, it could play a role in the collapse of neutron stars which would lead to the formation of black holes, or in structure formation during cosmological expansion.

If the vacuum-dominance effect exists and is strong enough to have such consequences, scientists will still have to discover a new kind of quantum field that would react to gravity in this way, since none of the quantum fields based on known forces could induce these effects. Still, the physicists note that the possibility of vacuum dominance itself is surprising to discover within “a simple and classically well-behaved situation.”

More information: Daniel Vanzella and William Lima. “Gravity-Induced Vacuum Dominance.” *Phys. Rev. Lett.* 104, 161102 (2010). Doi: 10.1103/PhysRevLett.104.161102.