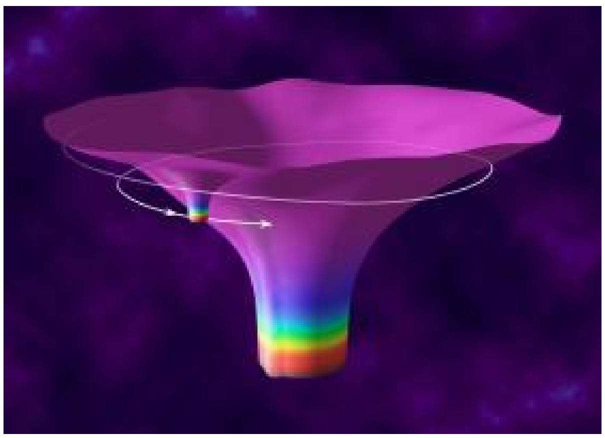
A Newtonian system that mimics the baldness of rotating black holes

February 23 2009



Clifford Will hopes to learn more about how small black holes orbit around rotating massive black holes in general relativity, where the relativistic Carter constant plays a key role. Illustration by Don Davis

(PhysOrg.com) -- The rotating black hole has been described as one of nature's most perfect objects. As described by the Kerr solution of Einstein's gravitational field equations, its spacetime geometry is completely characterized by only two numbers — mass and spin — and is sometimes described by the aphorism "black holes have no hair."

A particle orbiting a rotating black hole always conserves its energy and angular momentum, but otherwise traces a complicated twisting rosette pattern with no discernible regularity.

But in 1968, theoretical physicist and cosmologist Brandon Carter showed that the particle's wild gyrations nevertheless hold another variable fixed, which was named the "Carter constant." The true meaning of Carter's constant still remains somewhat mysterious 40 years after its discovery.

Now Clifford M. Will, Ph.D., the James S. McDonnell Professor of Physics in Arts & Sciences at Washington University in St. Louis, has shown that, even in Newton's theory of gravitation, arrangements of masses exist whose gravitational field also admits a Carter-like constant of motion, in addition to energy and angular momentum.

What's more, the deviation of the field's shape from being spherical is determined by a set of equations that are identical to those for Kerr black holes.

In his article "Carter-like Constants of the Motion in Newtonian Gravity and Electrodynamics" in the Feb. 12 issue of *Physical Review Letters*, Will points out that one Newtonian system that exhibits this property is surprisingly simple: two equal point masses at rest separated by a fixed distance.

"I was completely stunned when I saw that the Newtonian condition for a Carter constant was identical to the condition imposed by the black hole no-hair theorems," said Will. "Do I know why this happens? So far, not a clue.

"But what I really hope is that insights gained about this strange constant in the simpler Newtonian context will teach us something about how small black holes orbit around rotating massive black holes in general relativity, where the relativistic Carter constant plays a key role."

This will have implications for gravitational-wave astronomy, he says, because the signal from such events may be detectable by the advanced LIGO-VIRGO-GEO network of ground-based laser interferometric detectors or by the proposed space-based LISA (Laser Interferometer Space Antenna).

Will, who is also a visiting associate at the Institute of Astrophysics in Paris, is a theoretical physicist whose research interests encompass the observational and astrophysical implications of Einstein's general theory of relativity, including gravitational radiation, black holes, cosmology, the physics of curved spacetime and the interpretation of experimental tests of general relativity.

Will's "Was Einstein Right?" (1986) won the American Institute of Physics Science Writing Award. His "Theory and Experiment in Gravitational Physics" (1981) is considered the bible of the field.

Provided by Washington University in St. Louis