On the deceleration behaviour of black holes

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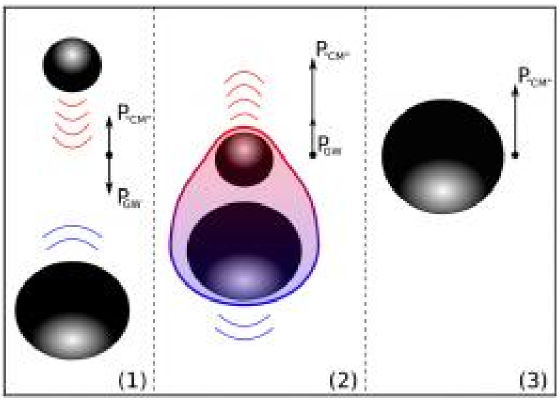

Kicking about in space: Researchers have modelled the collision of black holes (1). Thereby it was shown that the newly created black hole is initially deformed (2). To smooth this asymmetry and achieve the energetically more favourable spherical shape, more momentum is radiated upwards: this "anti-kick" decelerates the black hole slightly - it now continues to move with reduced speed (3). Image: MPI for Gravitational Physics

(PhysOrg.com) -- Researchers use the concept of "anti-kick" to explain why the speed suddenly decreases after the collision of such exotic objects.

Kicking is not only associated with football: if two black holes approach each other so closely as to collide and merge, the resulting black hole recoils and then races through the universe at a speed of up to several thousand kilometres per second. Sometimes, however, it experiences a sudden decrease in speed - a behaviour for which there was no convincing explanation. Scientists from the Max Planck Institute for Gravitational Physics have now found a solution to the puzzle: there is a type of recoil in the opposite direction that reduces the speed of the whole system. In this "anti-kick" the black hole emits gravitational waves to reach its energetically optimum shape: a sphere. (Physical Review Letters, June 3, 2010)

Viewed from the outside, a black hole is not a tangible object but a region in space that draws in matter from its surroundings with great force. The boundary which separates this region from the rest of space is called the horizon. In the simplest case, the horizon is perfectly spherical and floating in space. Anything crossing the horizon from the outside is unable to leave again. Not even light can escape this gravitational trap - hence its name. Black holes are considered to be important components of models which astrophysicists use to explain stellar evolution or the interior of active galactic nuclei.

Luciano Rezzolla, head of the ‘Numerical Relativity’ research group at the Max Planck Institute for Gravitational Physics (Albert Einstein Institute, AEI), and his colleagues Rodrigo Macedo and José Luis Jaramillo started by examining a simple system. In this model, a smaller and a large black hole move linearly towards each other and collide head-on. The smaller black hole moves faster, has a high downward momentum and emits strong gravitational waves downwards. Since every action also produces a reaction, the overall system moves upwards - this is the "kick" (left part of Fig.).

The black hole produced by the merger is initially not spherical, but deformed and has a type of "bump" at the top (central part of Fig.). To smooth this asymmetry and achieve the energetically more favourable spherical shape, more momentum is radiated upwards by means of gravitational waves: this "anti-kick" therefore decelerates the resulting black hole. It still moves upwards, albeit at a reduced speed (right part of

Fig.).

"This simple model takes us a lot further towards understanding black hole collisions. In our publication we provide an intuitive explanation for a process whose mathematical details are terribly complex," says Luciano Rezzolla. "It is important in physics to understand complex phenomena and provide clear explanations. This is the significance of the research results of Rezzolla and his team," adds Bernard F. Schutz, Director of the Astrophysical Relativity Division.

The generation of a large kick in the merger of black holes has a direct impact in astrophysics: Depending on its size, in fact, it determines the number of galaxies containing supermassive black holes at their centres since black holes can even be kicked out of their galaxies. The explanation of the anti-kick suggests a methodology to probe the physics around a black hole by monitoring the geometry near its horizon. This approach may help understanding some fundamental aspects of black-hole physics.

More information: Luciano Rezzolla, Rodrigo P. Macedo and José Luis Jaramillo, 'Understanding the "anti kick" in the merger of binary black holes', Physical Review Letters, June 3, 2010, prl.aps.org/abstract/PRL/v104/i22/e221101

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