LIGHT DAVID DEFEATS THE SUPERMASSIVE GOLIATH
or how to weigh small particles with supermassive black holes

Supermassive black holes can be used to measure the mass of extremely light particles to unprecedented levels and rule out the existence of new exotic particles, perhaps constraining the nature of dark matter. These are the results of a recent study to be published in the prestigious Physical Review Letters.

Most of our knowledge of the Universe comes from electromagnetic waves, which travel through vacuum at the speed of light (300 thousand kilometers per second). Electromagnetic waves are carried by photons, elementary particles whose mass must be exactly zero if they travel at precisely the speed of light. If photons had mass their speed would be slower, drastically affecting our understanding of particle physics and of the whole Universe.

BLACK HOLES AS LABORATORIES FOR PARTICLE PHYSICS

Traditionally, particles are studied by colliding them in accelerators. Ultra-light particles, however, are hard to study in this way. This is one reason why researchers have started to investigate the possibility of using precise astrophysical observations to probe the microscopic world. By studying how particles interact with black holes it is possible to estimate not only their masses, but even their very existence.

Supermassive black holes are huge gravitational objects typically located at the center of galaxies, including our Milky Way. When black holes rotate (and most do), they display an interesting effect known as "superradiance": if one shines a lamp on a rotating black hole, the beam reflected off the black hole is brighter! This happens at the expense of the hole's kinetic energy: after the reflection, the black hole spin decreases.

BLACK HOLES AND MASSIVE PHOTONS

In recent work, an international team of researchers at IST (Portugal), Rome (Italy), Mississippi (USA) and Osaka (Japan) showed that ultralight photons with nonzero mass would produce a "black hole bomb": a strong instability that would extract energy from the black hole very quickly. Therefore the very existence of such particles is constrained by the observation of spinning black holes. With this technique the authors have succeeded in constraining the mass of the photon to unprecedented levels: the mass must be smaller than 10^-20 electron-volt, or one hundred times better than the current bound. To put this in context, this mass is one hundred billion of billions times smaller than the present constraint on the neutrino mass (about two electron-volt).

The results of this study can be used to investigate the existence of new particles, as those possibly contributing to the dark matter that are currently being searched for at the LHC at CERN. Can observations of supermassive black holes provide new insights which are not accessible in laboratory experiments? This would certainly be exciting. Perhaps these new frontiers in astrophysics will give us a clearer understanding of the microscopic Universe.