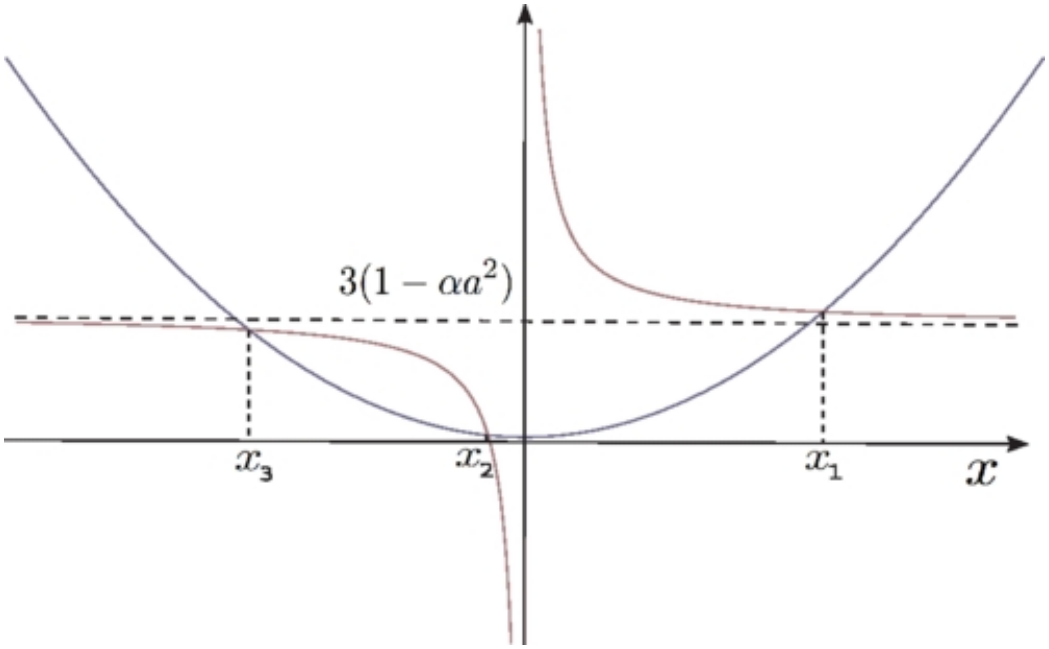
Theoretical physicists at CECs reveal a new three-dimensional black hole, which permit a more general approach to the determination of black hole masses in presence of matter.



The analytical solution developed by CECs physicists was published recently in *PHYSICAL REVIEW D* , and is part of the research on couplings of matter to black holes. In particular, the study considered the conformal coupling of a spin 0 field, so-called “scalar field” and of a spin 1 field, known as “gauge field”, in spacetimes with negative cosmological constant in three dimensions.

Marcela Cárdenas , a PhD student at CECs Theoretical Physics Laboratory, supervised by Cristián Martínez , states that “this research was performed in the context of a three dimensional gravitational theory, which is, in principle, a ‘toy model’ because it does not contain the four known spacetime dimensions”. Models and solutions in three-dimensional spacetimes have been very useful from a theoretical point of view, given that they can provide systems that are simpler to analyze than their analogues in four dimensions, and that despite the dimensional reduction, they still hold the physical properties that are desirable for study in four dimensions.

The paper reports an “exact black hole solution in three dimensions” endowed with a scalar field and a gauge field with “conformal coupling”. In other words, “gravity” is connected to the simplest field of matter (scalar field) and electric charge “where the action of matter” of the theory has an additional symmetry that is the conformal symmetry, i.e. the invariance under scale transformations, indicates Marcela Cárdenas.

“The term ‘conformal coupling’ refers to the fact that the energy-momentum tensor of matter has null trace, it vanishes, as a product of the invariance under scale transformations of the Lagrangian of matter. On introducing this property into the Lagrangian of matter fields, we obtain a family of black hole solutions that are endowed with electric charge and a regular scalar field outside the event horizon”, adds Óscar Fuentealba , theoretical physicist and PhD student of the Physics Lab.

The published article also contains a detailed analysis of the behaviour of the gravitational field and the matter fields in the region that corresponds to spatial infinity, and of boundary conditions that allow computation of the conserved charges of the black hole solution, in this case its mass and electric charge. The effect of boundary conditions on the matter fields illustrates what could occur in four or higher dimensions.

The work also investigates the thermodynamics of these types of solutions and explicitly shows that the conserved charges of these black holes obey the first law of thermodynamics.

Reference: Cárdenas, M; Fuentealba, O.; Martínez, C. (2014): *Three-dimensional black holes with conformally coupled scalar and gauge fields*
Phys. Rev. D 90, 124072 – Published 24 December 2014 DOI: http://dx.doi.org/10.1103/PhysRevD.90.124072