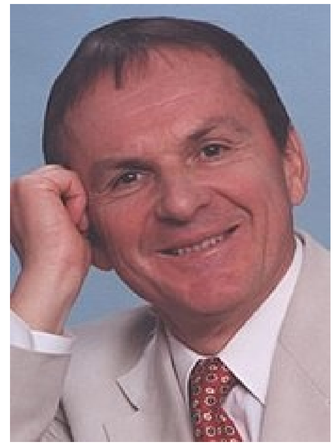
Vortices and GIMPs (Gravitationally Interacting Massive Particles)

Hagen Kleinert

Freie Universität Berlin,

Germany

http://users.physik.fu-berlin.de/~ag-kleinert/kleinert



Path Integrals are an important tool for controlling fluctuations in Quantum and Statistical Physics up to Financial Markets [1,2]. Recently, they have also become relevant in Cosmology, where they govern the appearance of dark matter [3].

Nearly 23% of matter in the universe is so-called ’dark matter’, which does not couple to any of the known fields in the table of elementary particles. Since its discovery there have been many speculations as to what their nature could be. The answer was anticipated as early as 1919 by Einstein himself when he speculated that all matter may ultimately be a solution of his vacuum equations. Indeed, we have meanwhile learned that the 72% of the so-called ’dark energy’ adds to the 23% of dark matter, which means that most of the universe follows Einstein's vacuum equations. Among the solutions are vortex-like and surface-like singularities of spacetime and the black holes formed from these. The latter do not couple to any other field because of their immense combined mass, which has been estimated by the Event Horizon Telescope to contain up to millions and billions of solar masses. Even though any individual particle in a black hole is completely normal, the black hole itself is so massive that no other particle can leave its regime making it appear dark.

Due to their purely gravitational character, the vortex-like and surface-like singularities and the super-massive black holes formed by their accumulation are subject to only gravitational interactions. They will therefore be called GIMPs as an abbreviation of 'Gravitationally Interacting Massive Particles'.

[1] H. Kleinert,
Path Integrals in Quantum Mechanics, Statistics, Polymer Physics, and Financial Markets,
5th Edition (World Scientific, Singapore, 2009).

[2] H. Kleinert and V. Schulte-Frohlinde, *Critical Properties of φ^4-Theories*
(World Scientific, Singapore, 2001).

[3] H. Kleinert, Particles and Quantum Fields
(World Scientific, Singapore, 2016). See Chap. 31.