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The newborn black hole in GRB 191014C proves that it is *alive*

Press release

A new theory explains the high-energy (photon energies of gigaelectronvolts — GeV) observed in the energetic long-duration gamma-ray bursts (GRBs) as originated in the vicinity of the black hole horizon. The theory, published today in *Astronomy & Astrophysics* [1], led by an ICRA-ICRANet research team (INAF associates), is based on the “*inner engine*” previously introduced by the team [2, 3]. The theory, which is also shown to work in active galactic nuclei (AGN), proves that the rotational energy of a black hole can indeed be extracted from the horizon of the black hole, and efficiently used to power the most energetic and powerful objects in the Universe.

Rotating black holes were initially conceptualized either as “*dead*” objects or as sinks of energy. Subsequently, it was realized that much as the thermodynamical systems, black holes may interact with their surroundings exchanging energy [4, 5]. This result led to one of the most important concepts in black hole physics and astrophysics: the Christodoulou-Ruffini-Hawking black hole mass-energy formula [4–6]. In its most general form, for a rotating charged black hole, it relates the black hole mass-energy to three independent pieces: its “*irreducible mass*”, its charge, and its angular momentum. It led to a corollary of paramount importance in astrophysics: up to 50% of the mass-energy of a charged black hole, and up to 29% of the one of a rotating black hole, could be in principle extracted!. This extraordinary result led to the alternative view of “*alive*” black holes, and since then it has permeated, for fifty years as of this writing, relativistic astrophysics both theoretically and experimentally.

The most energetic astrophysical sources, GRBs and AGN, were soon identified as primary candidates to be powered by black holes. GRBs, the most powerful transient objects in the sky, release energies of up to a few 10^{54} erg in just a few seconds! Their luminosity in the gamma-rays, in the time interval of the event, is as large as the luminosity of all the stars of the observable Universe! GRBs have been thought to be powered, by an up-to-now unknown mechanism, by stellar-mass black holes. AGN, releasing 10^{46} erg s^{-1} for billion years, must be powered by supermassive black holes of up to a few billion solar masses. However, every theoretical effort to find a mechanism to extract the black hole energy has been vanifed by the implausibility of their realization in nature (see, e.g. [7]).

There was the urgency of new physics!. The novel engine presented in the new publication makes the job through a purely general relativistic, gravito-electrodynamical process: a rotating black hole, interacting with a surrounding magnetic field, creates an electric field (see Fig. 1) that accelerates ambient electrons to ultrahigh-energies leading to high-energy radiation (see Fig. 2) and ultrahigh-energy cosmic rays (UHECRs). Aspects of this novel machine worth to be outlined are: (1) the nature of the emission results from the physical process leading to the electric and magnetic fields and the black hole formation. (2) The emission process is not continuous but discrete, it repeats over and over, releasing in every characteristic time a well-established “*blackholic quantum*” of energy [2], extracted from the black hole horizon thanks to the presence of a surrounding magnetic field. (3) Such a timescale, for GRBs, is as short as femtoseconds, making it difficult to be probed *directly* by current observational facilities. Direct evidence of the process discreteness might come out, instead, from AGN. In the case of M87*, the authors have predicted a high-energy (GeV) luminosity of a few 10^{43} erg s^{-1} , released in a timescale of up to tenths of seconds, while the timescale for UHECRs emission is of the order of half a day!

All the above results are important. The proof that we can use the extractable rotational energy of a black hole to explain the high-energy *jetted* emissions of GRBs and AGN stands alone. The *jetted* emission does not originate from an ultra-relativistic acceleration of matter in bulk (massive jets), but from very special energy-saving general relativistic and electro-dynamical processes leading to the emission of *blackholic quanta* of energy [2]. A long march of successive theoretical progress and new physics discovered using observations of GRBs has brought to this result which has been waited for about fifty years of relativistic astrophysics.

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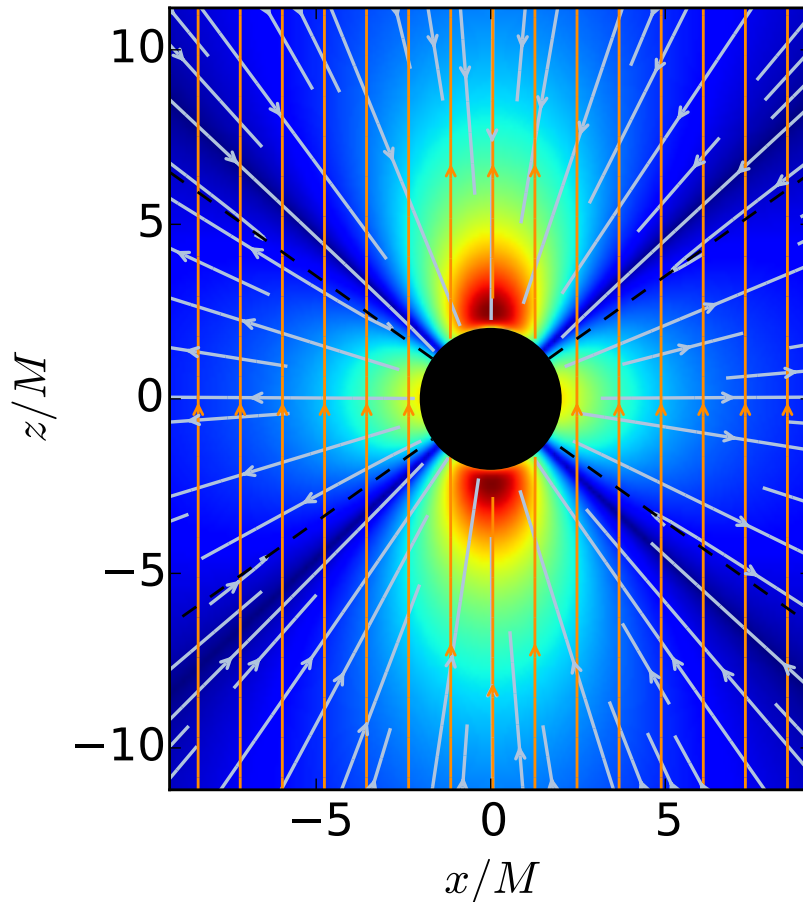


FIG. 1. Figure taken from [1] with the kind permission of the authors. Electric (blue lines) and magnetic (golden lines) field lines surrounding the rotating black hole. Electrons located in these northern and southern hemisphere cones of semi-aperture angle of $\sim 60^\circ$ are outwardly accelerated leading to GeV photons (see Fig. 2).

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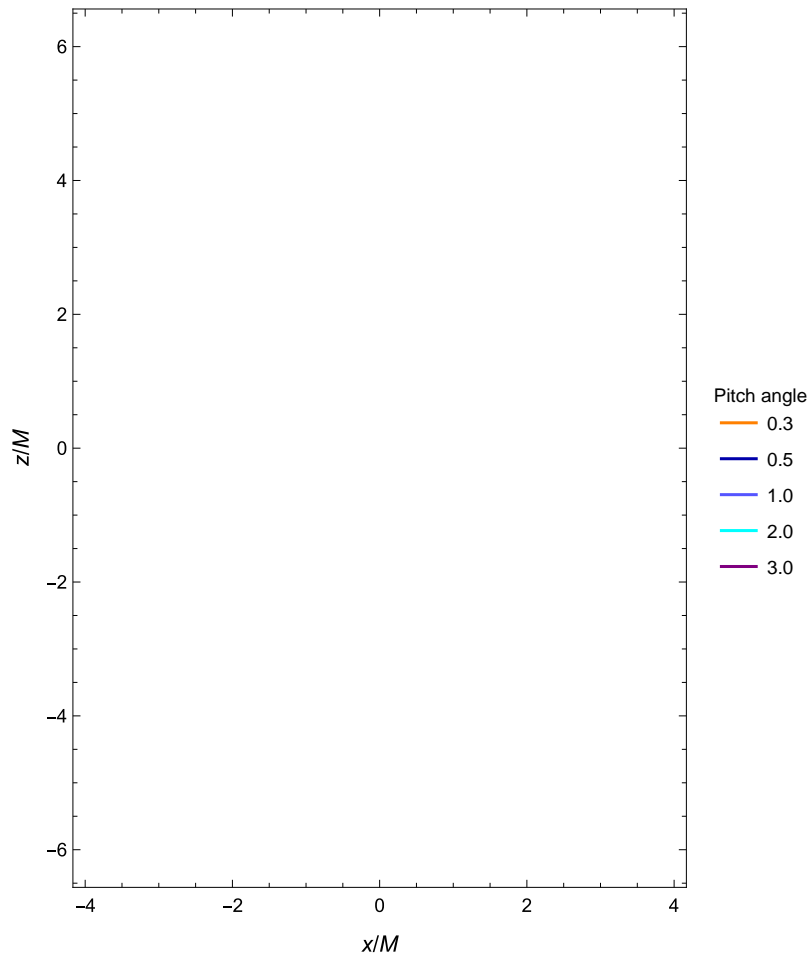


FIG. 2. Figure taken from [1] with the kind permission of the authors. Electrons are accelerated and emit GeV photons in the conical region with a semi-aperture angle $\theta = 60^\circ$ (dark boundary). This “*jettted*” emission is essential to infer the BdHN I morphology from the GeV emission data of long GRBs [8].