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**Review of the doctoral dissertation**
**by Bestin James**
**entitled "Modeling Magnetized Jets**
**from Accreting Black Holes"**

The PhD thesis of Mr. Bestin James concerns numerical studies of production and properties of magnetized jets by accreting, rotating black holes. The doctoral dissertation is composed of Introduction, description of numerical methods, and three papers:
-- P1: "Variability of Magnetically Dominated Jets from Accreting BlackHoles";
-- P2: "Modeling the Gamma-Ray Burst Jet Properties with 3D General Relativistic Simulations of Magnetically Arrested Accretion Flows";
-- P3: "Black hole outflows initiated by accretion of large-scale magnetic fields".
All of these papers were completed under the guidance of Prof. Agnieszka Janiuk at CTP PAS, Warsaw. The first two were already published (Janiuk, James & Palit 2021, ApJ; James, Janiuk & Nouri 2022, ApJ), the third -- with Mr. James as a first author is under preparation for submission.

Results presented in these papers are based on numerical simulations performed by Mr. James. They were performed using GRMHD code named HARM, which was developed in 2003 by Gammie, McKinney & Toth (2003: ApJ, 589, 444 [2003]). Adoption in this code of the Kerr-Schild coordinates allows to follow accretion of matter onto the BH down to its horizon and to prove prediction of Blandford and Znajek (1977), that production of jets can be powered by rotation of the black hole. Production of such jets can take place in AGNs, GRBs, and in XRBs. Unfortunately complexity of MHD inflows in the BH vicinity and uncertainties regarding evolution of accretion flows thread by large scale magnetic fields plus computing time constraints still necessitates making variety of simplifications. They are extensively discussed by Mr. James in the context of his results presented in his Thesis.

Let me start my review with comments regarding the Introduction. It begins with basic theoretical knowledge about structure of black holes. That is followed by a broad review of accretion processes. Then radiative processes and plasma instabilities are presented. And finally basic knowledge about astrophysical sources of relativistic jets is provided. The Introduction is 35 pages long, but could be much shorter if focused on the issues closer related to problems studied in the Thesis. An example of nice and compact presentation is e.g. the sub-section about plasma instabilities. My specific critical comments on Introduction concern two issues: confusing way of presentation there classification of accretion disks, and the lack of information whether (and how if yes) reconnection of magnetic fields was included in simulations contributing to results presented in the Thesis.

Regarding the accretion disk classification, let me start with pointing out, that contrary to information contained in the caption to Fig 1.3 about its origin, I didn't find it in the cited there paper by Abramowicz and Fragile 2013. And my critical comments regarding the way Mr. James presents the classification on p. 20 of his Thesis are:

-- "the thin disks" are defined there to be geometrically thin and optically thick, and to be slowly rotating and having efficiency about 0.1, whereas theory of standard accretion disks predicts, that they can be formed around BH with any value of dimensionless spin enclosed within the range [0;1] and for fastest rotating BHs getting efficiency up to around 0.4 ( see Novikov & Thorne 1973);

-- "the thick disks" are defined there to be geometrically thick and optically thin, whereas geometrically thick disks can be formed both at very low accretion rates and at very high accretion and in the latter case they are optically thick (see e.g. Sikora 1981) .

And regarding magnetic reconnection process. Despite that it's importance is noticed in many places of Thesis, as playing crucial role in production of outflows from vicinity of rotating BHs, I didn't find information, whether it was included in the computed by Mr. James models. It is known, that in the first approximation it can be adopted in MHD simulations by including resisitivity which acts as a proxy for kinetic effects leading to plasmoid formation. But since PIC simulations are required to follow formation of plasmoids, my question is how it is counted in global accretion flows and outflow dynamics.

My critical comments regarding the paper P1:

It is proposed in this paper that indicated by observationally suggested anticorrelation between mean values of Lorentz factors of jets in GRBs and AGNs and their minimal variability time scales can be explained assuming that the minimum time scale of variability is determined by MRI. Since it was studied using 2D HARM simulations, while in reality accretion of innermost portions of disks in such objects is expected to proceed via Rayleigh-Taylor instabilities, one might expect that minimal time scale is not related to MRI which in magnetically arrested disks are expected to be suppressed.

My critical comments regarding the paper P2:

It is proposed there that types and parameters of equilibrium tori – used to initiate MHD simulations leading to formation of magnetically arrested disks -- can be connected with properties of relativistic outflows of GRBs is in my opinion too optimistic. In order to run by present day such simulations, the distance of such tori from the center cannot be larger than 100 gravitational radii (see, e.g., Chatterjee et al. (MNRAS 490, 2200 [2019]), too small to associate them with specific classes of events.

And my comments regarding the ongoing paper P3:

There are performed studies of effects of mass inflows and outflows driven by a large scale asymptotically uniform magnetic field starting from a spherically symmetric inflows. Such conditions may correspond with conditions around supermassive BHs in Sgr A and M87, which observationally can be followed down to their horizons and therefore can be used to match theory and observations within the same distance ranges. Presented there results support theoretical predictions regarding formation in such objects the magnetically arrested disks.

Let me complete my review with the following summary. The development of numerical GR MHD code by Gammie et al. that allows tracking of accretion matter with large-scale magnetic fields down to black hole horizons opened a new era in studies of outflows produced in such objects as AGN, GRB and BH XRB. Mastering this code to such an extent that one can manage modifications to make it applicable to a wide range of studied astrophysical structures and to overcome the time limitations of simulations undoubtedly requires both deep theoretical and numerical knowledge. Declared by Mr. James and confirmed by co-authors his contribution to the works constituting the main part of his dissertation indicates that such a scientific level has already been achieved by him. And the results of his work undoubtedly add value to the currently deepened knowledge about the role of rotating black holes in the production of jets and winds in such compact objects as AGNs or GRBs.

Summing up, I consider the doctoral thesis of Mr Bestin James to be a valuable contribution to science and to meet the criteria prescribed by the law for a doctoral dissertation. Therefore, I request that this dissertation be admitted to a public defense.

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