MAX-PLANCK-INSTITUT FÜR GRAVITATIONSPHYSIK
ALBERT-EINSTEIN-INSTITUT (AEI)

Am Mühlenberg 1, D-14476 Golm bei Potsdam, Germany

Prof. Dr. Luciano Rezzolla
Head of Numerical Relativity, AEI
Tel/Fax: +49-331-567-7246/52
webpage: www.aei.mpg.de/~rezzolla

Prof. Zdeněk Němeček, Dean
Studijní oddělenı-doktorské studium
Ke Karlovu, 3
121 14 Praha 2

Potsdam, 3/8/2011

Dear Prof. Němeček, Dear Colleagues,

What follows is my evaluation of the Ph.D. Thesis of Mgr. **Ondřej Kopáček**, entitled *Transition from regular to chaotic motion in black hole magnetospheres*.

The Thesis reports the research work carried out during the PhD studies and covers two main aspects: the structure of the electromagnetic field around a rotating black hole and the motion of charged matter. Both topics are of great relevance in relativistic astrophysics and although the subject of studies since decades, they still offer many opportunities for novel and interesting results.

With reference to the first topic covered by the Thesis, Mgr. Kopáček has studied in particular the interplay between the frame-dragging effect and an asymptotically uniform magnetic field, which can be either aligned or misaligned with respect to the rotation axis of the black hole. Particular importance has been paid to the role played by the choice of suitable observers and of the different description that they can perform of this problem. In the course of this research Mgr. Kopáček has highlighted that the "Meissner effect", i.e. the expulsion of the aligned magnetic field out of the horizon of an extremal Kerr black hole is observer-dependent and does not appear, for instance, in the tetrad of a ZAMO observer. In addition, when a perpendicular component of the magnetic field is added, the latter is not expelled and the electromagnetic fields acquire a complex and layered structure which appears to be quite independent of the choice of observers. These are very interesting results, which have helped clarify this aspect of the electrodynamics of rotating black holes. Finally, when the rotating black hole is considered to be in motion, Mgr. Kopáček has found a number of interesting results which I cannot list all here. I found particularly revealing the fact that under these conditions the electric and magnetic fields lead to the formation of neutral points which are not coincident. It is at these points that magnetic reconnection (with consequent energy release) can take place, or where charged particles injected would be accelerated effectively without the influence of the magnetic field.

MAX-PLANCK-INSTITUT FÜR GRAVITATIONSPHYSIK
ALBERT-EINSTEIN-INSTITUT (AEI)

Am Mühlenberg 1, D-14476 Golm bei Potsdam, Germany

With reference to the second topic covered by the Thesis, Mgr. Kopáček has studied the motion of charged particles near a magnetized and rotating black hole or neutron stars. The interest in this case was to consider and distinguish motion which is chaotic from the one which is instead regular. Also in this case I will not enter into the details of the numerous cases studied and of the results obtained. However, it is particularly worth mention the introduction of Recurrence Plots in place of the standard Poincaré maps to study the occurrence of chaotic motion. This new technique has not been employed before in general-relativistic contexts, but it has been shown by Mgr. Kopáček to be particularly useful and effective.

Overall, the Thesis is very well written and pleasant to read. All aspects are treated clearly, with a detailed discussion of the previous results in the literature, an accurate presentation of the results obtained. Many of the results presented are scientifically new and the techniques employed to derive these results rather innovative in a general-relativistic context. I am confident that other scientists will find these techniques useful and will adopt them in further developments of this work.

The results presented and the publications in which Mgr. Kopáček appears as first author, certify that has shown ability for creative and interesting scientific work, and is well qualified for a Ph.D. degree. Within a German academic system I would be glad to recommend the mark of **"magna cum laude"** to this Thesis.

Sincerely,

Luciano Rezzolla
Head of Numerical Relativity, AEI