

**Marek Abramowicz, opponent of habilitation work by Jan Shee,  
"Optical phenomena probing the gravitational field of compact objects  
governed by alternative theories of gravity"**

**Opinion**

In short, my opinion on Dr Shee's habilitation work is very positive, and my conclusion is that he deserves to be promoted.

**1. His choice of research subject and methods is wise and ambitious**

We are at the advent of a new era when theories of gravity, alternative to Einstein's general theory of relativity, may be, and will be, observationally checked in the strong field regime – for the first time ever. This is of a fundamental importance for physics, and even more widely – for culture in terms of the world-view.

Dr Shee quite rightly writes that: "In order to find out which of the proposed theories can be taken seriously, one has to compare their predictions with observations of astrophysical objects where black holes (naked singularities, or so called superspinars) could be expected. So far, the information about the phenomena taking place in strong gravity astrophysical systems can be acquired from the electromagnetic radiation of a source being either a part of the strong gravity astrophysical system (e.g. the accretion disc), or can be far from the system of interest, but the source's radiation that we detect is influenced by the gravitational lensing effects on the strong gravity system." This is his research program executed in the thesis. His particular choice of the alternative theories is, again in his own words: "In the present thesis attention is focused on the braneworld black holes and naked singularities, Hořava gravity black holes and naked singularities, and regular black hole or no-horizon spacetimes being solutions of GR combined with non-linear electrodynamics."

In my opinion this was an excellent choice, putting Dr Shee's research at the world-class category.

As for methods, he was mostly studying behaviour of geodesics in metrics given by known functions. Although this is a rather standard approach, being used by many other researchers in the field, it is not at all an easy task. Using these methods, in particular the method of "ray-tracing", is demanding analytically and numerically, and requires a very specific, expert knowledge.

**2. Introductory Part I is a well composed and competent review**

Part I gives a concise and accurate description of several theories of gravitation. It starts with the Einstein General Relativity (GR) and its version equipped with non-linear electrodynamics. Then description of Bardeen's and ABG spacetimes follows. The Braneworld models are discussed in the context of Reissner-Nördström and Kerr-Newman braneworld geometries. At the end, he gives a review of the Hořava gravity and in particular the Kehagias-Sfetsos geometry. The rest of Part I is devoted to explaining, in relevant details, specific

methods that he uses in his research.

Dr Shee shows solid knowledge of the subject and also a remarkable pedagogical abilities in explaining difficult and complex issues. Part I has a clear logical structure that helps to grasp Dr Shee explanations.

### **3. Part II: results obtained are serious and interesting**

I was aware of most of the results presented in Part II, which is a choice of Dr Shee's published research papers. They are important contributions to the field. This is the chronological list of them:

2009

1. **Schee**, J. and Stuchlík, Z., *Optical Phenomena in the Field of Braneworld Kerr Black Holes*, Int. Jour. of Mod. Phys. D, 18, 06, pp. 983-1024

2. **Schee**, J. and Stuchlík, Z., *Profiles of emission lines generated by rings orbiting braneworld Kerr black holes*, Gen. Rel. and Grav., 41, pp.1795-1818

2010

3. Stuchlík, Z. and **Schee**, J., *Appearance of Keplerian discs orbiting Kerr superspinars*, Class. And Quant. Grav., 27, 215017

2012

4. Stuchlík, Z. and **Schee**, J., *Counter-rotating Keplerian discs around Kerr superspinars*, Class. And Quant. Grav., 29, 025008

5. Stuchlík, Z. and **Schee**, J., *Observational phenomena related to primordial Kerr superspinars*, Class. and Quant. Grav., 29,065002

2013

6. **Schee**, J. and Stuchlík, Z., *Profiled spectral lines generated in the field of Kerr superspinars*, Jour. of Cosmolog. and Astropart. Phys., 4, 005

2014

7. Stuchlík, Z. and **Schee**, J., *Optical effects related to Keplerian discs orbiting Kehagias-Sfetsos naked singularities*, Class. and Quant. Grav., 31, 195013

2014

8. Stuchlík, Z., **Schee**, J., and Abdujabbarov, A., *Ultra-high-energy collisions of particles in the field of near-extreme Kehagias-Sfetsos naked singularities and their appearance to distant observers*, Phys. Rev. D, 89, 104048

2015

9. **Schee**, J. and Stuchlík, Z., *Gravitational lensing and ghost images in the regular Bardeen nohorizon spacetimes*, Jour. of Cosmolog. and Astropart. Phys., 6, 048

2016

10. **Schee**, J. and Stuchlík, Z., *Profiled spectral lines generated by Keplerian discs orbiting in the Bardeen and Ayon-Beato-Garcia spacetimes*, Class. and Quant. Grav., 33, 085004

11. **Schee**, J. and Stuchlík, Z., *Silhouette and spectral line profiles in the special modification of the Kerr black hole geometry generated by quintessential fields*, Europ. Phys. Jour. C, 76, 643

2017

12. Stuchlík, Z., Blaschke, M., and **Schee**, J., *Particle collisions and optical effects in the mining Kerr-Newman spacetimes*, Phys. Rev. D, 96, 104050

My comment here is that all these 12 papers have been published in top world journals, including The Physical Review. For 6 of them Dr Schee is the first authors. Zdeněk Stuchlík co-authored of all these papers.

#### 4. My overall judgement

I am impressed by competence and professionalism shown by Dr Shee in his habilitation thesis. Working on a research that is on the front-line of today's physics he obtained significant results and publish articles describing them in world's leading journals. He described these results in his thesis in a clear, logical and pedagogical way, explaining a wider context of their importance in the search for alternative theories of gravity.

He deserves habilitation.

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