

Report on the PhD thesis by Morteza Kerachian

I know Mr Kerachian from autumn 2014 when he started his Doctoral programme studies at our Institute of Theoretical Physics. He came from the University of Cyprus where he finished his undergraduate studies.

He wished to work in general relativity. In order to obtain PhD in theoretical physics (specifically in general relativity), one first has to pass some quite difficult examinations in such fields like modern differential geometry, quantum field theory and, of course, advanced general relativity. Morteza's knowledge in these subjects was rather limited but he studied quite hard and eventually passed all the examinations required. Later, during 2017, he also passed State Doctoral Examination. I appreciate his determination and strong will to accomplish this goal. However, because of this effort he did not have enough time for doing research in order to prepare a dissertation (based on published research papers) within the period of four years during which a PhD study at our Faculty is officially supported.

This has changed during recent years. Originally, I suggested to Morteza to work on the problem of fields of uniformly accelerated sources in the Friedmann-Lemaitre-Robertson – Walker (FLRW) universes by using conformal mapping from Minkowski spacetime. This turned out not so easy but Morteza did some work on charges in Milne Universe (suitably interpreted as the part of Minkowski space) which still may be worth looking at and possibly write a paper. However, Morteza did produce an original fine paper on uniformly accelerated traveller in FLRW universes, published recently by himself as the only author in Phys. Rev. D where the case of Milne universe is included and also analytical results (in terms of hypergeometrical functions) for the world-line of an uniformly accelerated observer in FLRW are presented. Morteza's work also indicated he has useful skills in using suitable algebraic manipulations like MAPLE etc.

Since about two years ago, Morteza Kerachian joined Giovanni Acquaviva and Georgius Lukes-Gerakopoulos, two former postdocs who started at our Einstein Center, now are at the Institute of Astronomy, Czech Academy of Sciences. They wrote two extended papers together, published in Phys. Rev. D, in both of them M. Kerachian is the first author. Generally speaking, they investigated "qualitative cosmology" in FLRW universes by employing the methods of dynamical systems. The titles of their two papers, "Dynamics of classes of barotropic fluids in spatially curved FRW spacetimes" and "Classes of nonminimally coupled scalar fields in spatially curved FRW spacetimes", clearly indicate their content. Suitable dimensionless variables need to be introduced, the autonomous systems of ODEs are obtained and then the critical points, lines or planes are investigated for various cases of the curvature index k of specific FRLW models and for various types of equations of state and scalar field potentials. Many parameter space portraits are plotted where, in

particular, an attention is paid to the regions/phases corresponding to an accelerating expansions.

Both co-authors, Drs Acquaviva and Loukes-Gerakopoulos, used the methods of dynamical systems in various contexts of the FLRW cosmology before (investigating, for example, effects of viscous pressure), and it is evident that they “taught” Morteza Kerachian these methods and have shown him how to produce nice plots in the parameter spaces. However, it appears clearly that Morteza turned out to be an efficient and especially diligent and full of zest researcher. In addition he produced nice figures (within Penrose’s diagrams) and results in his own paper. Also, the review parts of his thesis indicate that he has a good understanding of the subject.

I recommend his thesis to be acknowledged as the dissertation required for obtaining the title PhD from the Faculty of Mathematics and Physics of the Charles University.

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Prague, November 23, 2020