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Report on the Ph.D. thesis

Interacting Galaxies Magellanic Clouds and Milky Way

submitted by

Mr. Adam Růžička

In this judgement, I will first present a brief account of the scientific content and achievement of the presented thesis. After this, I will convey my general impression of the content and scope of the work, give comments on the overall written presentation, structure and layout of the thesis. I will finally express my recommendation concerning the candidate's eligibility to obtain the PhD degree after a successful defence.

Mr. Růžička has submitted a thesis dealing with numerical modelling of the dynamical evolution of the Magellanic Cloud System orbiting the Milky Way (MW), under mutual gravitational influences. The basis of this study is a fast and efficient parameter study of this system, greatly alleviated by the rich quantity of observational parameters. An interesting and cardinally important goal of such a study is the exploration of the shape of the gravitational potential of the Milky Way (dark) halo. The tool applied here is a code that finds the best match between numerical models and the observational data, viz. the distribution and kinematics of the neutral hydrogen observed in and around the Large (LMC) and Small Magellanic Cloud (SMC).

In his introduction, Mr. Růžička correctly states that there have been but few past studies of interacting galaxy pairs or groups of this kind, i.e. studies that try to reproduce genuinely existing situations. The necessary exploration of the parameter space necessitates a fast optimization tool, which in case of the present work is furnished by a genetic algorithm (GA), along with a restricted N-body simulation. Previous works on the MW-LMC-SMC system were not able to explore the parameter space but had to make assumptions about orbital and other parameters. In this respect, the submitted Ph.D. thesis constitutes the first exploitation of the parameter space of the MW-LMC-SMC system, facilitated by the close comparison with observational data. This is the HI survey of this system published by Brüns et al. (2005) and precise astrometry. Mr. Růžička points out that this observational material available for the Magellanic system is sufficient to plug in the indispensable constraints for the GA modelling. The final goal of this work is to model the past dynamical history of the Magellanic System and, as mentioned above, significant statements about the shape of the MW dark halo.

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The thesis presents an excellent description of the MW-LMC-SMC system and summarizes the observational evidence for the interaction history of the LMC and SMC, utilizing the most recent literature. Concerning the comparison of here performed numerical modelling with the data base, the focus is on the HI survey of Brüns et al. (2005), as it turns out that the observed morphology and kinematics of the Magellanic System, including the Stream and in particular the so-called Leading Arm, are most crucial. The parameter space (20 parameters, current locations, sizes, masses, velocities, shape of potentials) is explored via a restricted N-body model with test particles, whereby the Milky Way is assigned a logarithmic, flattened potential, while the LCM and SMC are described by Plummer spheres. The flattened MW halo is an important advancement compared to previous studies, and tidal friction by the MW halo is also accounted for. The reader is then acquainted with the properties of the genetic algorithm developed and used in this thesis project, and its implementation to the specific problem is outlined. A fitness function provides the connection between the observations and the genetic algorithm. Fourier filtering of the observed HI data cube turns out to be optimum for this treatment.

The kernel of the thesis then presents the results of no less than 10^6 tests of parameter combinations, incorporating a detailed analysis of the structure and kinematics of the gaseous constituent of the Magellanic System. It thereby turns out that the structure of the Magellanic Stream is crucial. The Leading Arm appears to be difficult to be properly account for. In essence, the most important inference resulting from this thesis is that only the outer disk of the LMC is disturbed, i.e. gas is tidally disrupted from there. In contrast, the SMC is subject to very strong tidal disruption for a short period of time, which gives rise to strong stripping of gas from it. This is inaccord with the rather clumpy distribution of the SMC gas. The overall shape of the Magellanic Stream is well reproduced, and, interestingly, the bulk of the stripped gas that finds itself in the Stream stems from the SMC, not from the LMC. The resulting shape of the MW halo that delivers the best-fit results is an oblate structure, this finding being one of the major improvements achieved in this thesis over previous investigations of this kind. Mr. Růžička finally also addresses the shortcomings of the restricted N-body code used here for the sake of computing speed. It is emphasized that future studies should also incorporate the dissipation of the gas, and implementing a tri-axial MW halo is deemed worth while.

The thesis presented by Mr. Růžička not only implies a respectable workload, but also manifests a research project of very high quality. The pursued strategy is thoughtful and manifests the candidate's high competence in this field. The excellent account of the relevant literature makes the corresponding chapter could a nice review for (e.g.) students to be introduced in the field. All necessary observational data or parameters have been collected with care. A remarkable number of simulations has been performed in this project, with significant results. These are obviously worth to be published in a refereed journal and will surely have their impact in this branch of astrophysical research. The methods are clearly spelled out, the thesis being well furnished with the necessary illustrations. I am also impressed by the quality of the language, with good phrasing, perfect spelling and only minor faults in grammar (which I think need not be corrected). In my view the presented thesis doubtlessly reflects the eligibility of Mr. Růžička to obtain the Ph.D. degree.

I hope that my statements will be helpful in the evaluation process, and I am looking forward to the disputation at Charles University.

Respectfully yours