MW-Gaia STSM

Piecing together the puzzle: the interaction between the Sagittarius dSph and the Milky Way

Pau Ramos Ramirez, PhD student at the Institute of Cosmos Sciences of the University of Barcelona enjoyed a one month stay (November 2019) at the Kapteyn Astronomical Institute (Groningen) thanks to a GP1 STSM grant to collaborate with Dr. E. Balbinot.

The aim of this project was to learn about the Milky Way potential through cutting-edge simulations of the accretion history of the Sagittarius Dwarf Galaxy. To do so, we must explore the role of the different actors at play: Large Magellanic Clouds, Dynamical Friction and Mass Loss. And, most importantly, understand how the effect of these agents can modify (or not) our fit of the Milky Way gravitational potential.

The ultimate goal is to piece together the puzzle of the interaction between the Milky Way and Sagittarius, which can help us understand the substructure of both the Dwarf (streams, internal kinematics, …) and our Galaxy (moving groups, phase-space spiral, outer disc structures, …).

During the first week, Pau Ramos started working on a framework that would allow the production of accurate yet cheap simulations of the Sagittarius stream given a Milky Way potential and a set of initial conditions (at the present). In other words, the simulations would start at present and then populate the tidal tails based on the orbit that the progenitor (Sagittarius) had in the past.

This framework should allow for different parts of the simulation to be switch on and off:

- Interaction with the Large and Small Magellanic Clouds.
- Dynamical Friction.
- Mass loss.

The work was developed on top of an already existing framework for galaxy dynamics. This implies a lack of full freedom, since it has to comply with the logic of the underlying code, but it offers a set of auxiliary functions already implemented. So, by the end of the first week, Pau Ramos had basically reproduced the results of the Vera-Ciro&Helmi 2013 paper in the fiducial case where none of the above mechanisms were acting.

During the second week, in collaboration with Dr. E. Balbinot, they implemented the interaction with the Large Magellanic Clouds (and, in fact, any other satellite could be added) and compared their results with those in Vera-Ciro&Helmi 2013.

Once that the implementation was correct, the work on the Dynamical Friction part began. Following the approach described in Zentner et al. 2003 and introducing the equations in the framework, then they tested it thoroughly as to be certain that the results were quantitatively as expected. This required a careful treatment of the units and the transfer of data among modules in order to make it compatible with the pre-existing core of the framework.

In parallel, the implementation of the mass loss was being sketched. The loss of mass along the orbit is an effect caused by the tidal forces of the Milky Way acting on the

infalling satellite. An accurate treatment of the mass loss has been the interest of many studies and it is definitely not trivial if ones wants a general purpose simulator.

Therefore, the fourth week was devoted to the implementation of the mass loss. After exploring several recipes, a simple law was chosen: the mass is only lost at pericenter and in a fraction that depends only on the location within the host's potential. By doing so, even if the complexity of the dynamics of tidal stripping cannot be captured, this recipe is easily reversible in time and is accurate enough for the purpose of reconstructing the orbit of Sagittarius.

On the last week, the work was devoted on refining the code, started exploring the modules that allows populating the tails of the stream and also a first sketch of the Approximate Bayesian Computation algorithm to fit the Milky Way potential to the observations of the Sagittarius stream.

Main achievements

The development of a framework that can produce a prediction for the stream of Sagittarius given a set of parameters for the Milky Way potential, fast enough to use it within a fitting algorithm. Moreover, it can consider different effects acting on the infalling satellite, either all together, separately or in any permutation wanted.

- A paper was produced: "Full 5D characterisation of the Sagittarius stream with Gaia DR2 RR Lyrae" P.Ramos, C.Mateu, T.Antoja, A.Helmi, A.Castro-Ginard, E. Balbinot, J.M.Carrasco. A&A 638, A104 (2020) https://arxiv.org/abs/2002.11142

FUTURE COLLABORATIONS (if applicable)

After the visit they planned a second visit another visit to the Kaptyen Astronomical Institute for end of January – early February of 2020 In order to finish the project successfully. Furthermore, with the tools developed during this project, they could go one step further and start answering other questions about the observed morphology of other streams, which is an active line of research and also one of the main interests of Dr. E. Balbinot.

The STSM gave Pau Ramos the opportunity to start a new collaboration that he still maintains to this day. After the paper resulting from the STSM, they collaborated again in a couple other papers and, more importantly, they have a line of communication open for future research ideas.