III Gaia Challenge III Workshop programme

Main talks will be in Lecture Sala Cassasses (please see the map in the Gaia Challenge wiki)
Working Group sessions will be in: Seminar-1 (spherical/triaxial); Seminar-2 (discs); Seminar-3 (streams/halo stars); Seminar-4 (collissional systems)

Monday	**Chair: F. Figueras**	**Welcome; Gaia Review**
10:00-10:20	LOC	Welcome
10:20-10:40	Xavier Luri (UB)	Gaia Status & Releases
10:40-11:00	Xavier Luri (UB)	Preparation of the Gaia Archive
11:00-11:30	**Coffee**	
11:30-13:00	Structured WG	WG discussion
13:00-14:00	**Lunch**	
14:00-15:30	Structured WG	WG discussion
15:30-16:00	**Coffee**	
16:00-16:30	WG leaders	Report back from working groups
16:30-17:30	UB team	Tutorial Session: Gaia Errors Computation
Tuesday	**Chair: J. Read**	**Spherical/Traixial systems**
9:00-9:30	Justin Read	Spherical/triaxial WG so far and our future plans
9:30-10:00	Gary Mamon	The rapid Bayesian MAMPOSSt algorithm
10:00-10:30	Laura Watkins	Jeans models on test problems
10:30-11:00	**Coffee**	
11:00-12:30	Structured WG	WG discussion
12:30-14:00	**Lunch**	
14:00-15:30	Structured WG	WG discussion
15:30-16:00	**Coffee**	
16:00-16:30	WG leaders	Report back from working groups
16:30-17:30	M. Gieles & A. Zocchi	Tutorial session: Lowered Isothermal Model Explorer in PYthon (LIMEPY): Install, run, plot, fit
Wednesday	**Chair: D. Kawata**	**Discs**
9:00-9:30	Eugene Vasiliev	Action-based modeling
9:30-10:00	J. Hunt / D. Kawata	Peculiar kinematics around the co-rotating spiral arms
10:00-10:30	M. Romero-Gómez	Gaia detection of response spiral arms
10:30-11:00	**Coffee**	
11:00-11:30	Jorge Peñarrubia	A new probability theory for the evolution in time-dependent potentials
11:30-12:00	Hamish Silverwood	The Dark Matter density at the solar position
12:00-12:30	J.G. Fernádez-Trincado	Preparing the 6D phase-space of the Besançon Galaxy Model
12:30-14:00	**Lunch**	
14:00-15:30	Structured WG	WG discussion
15:30-16:00	**Coffee**	
16:00-16:30	WG leaders	Report back from working groups
16:30-17:30	J. Hunt	Tutorial session: PRIMAL and SNAPDRAGONS

Thursday	**Chair: M. Giles**	**Collisional systems**
9:00-9:30	Ian Claydon	Explaining the flattening of velocity dispersion in globular clusters using Newtonian dynamics
9:30-10:00	Miklos Peuten	Mass segregation and stellar-mass black holes in star clusters
10:00-10:30	Alice Zocchi	On the uniqueness of kinematical signatures of intermediate-mass black holes in globular clusters
10:30-11:00	**Coffee**	
	Chair : A. Font	**Streams / Halo stars**
11:00-11:30	Robyn Sanderson	Streams and Halo stars WG so far and our future plans ?
11:30-12:00	Teresa Antoja	Detection of Ultra Faint Dwarf Galaxies with Gaia
12:00-12:30	Andreas Küpper	Streakline modeling of globular cluster streams
12:30-14:00	**Lunch**	
14:00-15:30	Structured WG	WG discussion
15:30-16:00	**Coffee**	
16:00-18:00	D. Marshall (coord)	Open seminar on the 3D extinction Map in the Gaia Era
Friday 4th	**Chair: T. Antoja**	
9:00-10:30	Structured WG	WG discussion
10:30-11:00	**Coffee**	
	Chair: ---	**Final report**
11:00-11:30	Justin Read	Spherical / triaxial
11:30-12:00	Daisuke Kawata/Douglas Marshall	Discs and extinction map
12:00-12:30	Andreas Küpper/Andreea Font	Streams & halo stars
12:30-13:00	Mark Gieles/Vincent Henault-Brunet	Collisional systems
13:00-14:00	**Lunch**	

Abstracts:

Antoja, Teresa - **Detection of Ultra Faint Dwarf Galaxies with Gaia**

We present a method to identify Ultra Faint Dwarf Galaxy (UFDG) candidates in the halo of the Milky Way using the future Gaia catalogue and we explore its detection limits and completeness. The method is based on the Wavelet Transform and searches for over-densities in the combined space of sky coordinates and proper motions, using kinematics in the search for the first time. We test the method with a Gaia mock catalogue that has the Gaia Universe Model Snapshot (GUMS) as a background, and use a library of around 30 000 UFDGs simulated as Plummer spheres with a single stellar population. For the UFDGs we use a wide range of structural and orbital parameters that go beyond the range spanned by real systems, where some UFDGs may remain undetected. We characterize the detection limits as function of the number of observable stars by Gaia in the UFDGs with respect to that of the background and their apparent sizes in the sky and proper motion planes.

We find that the addition of proper motions in the search improves considerably the detections compared to a photometric survey at the same magnitude limit. Our experiments suggest that Gaia will be able to detect UFDGs that are similar to some of the known UFDGs even if the limit of Gaia is around 2 magnitudes brighter than that of SDSS, with the advantage of having a full-sky catalogue. We also see that Gaia could even find some UFDGs that have lower surface brightness than the SDSS limit.

Ian Claydon: "Explaining the flattening of velocity dispersion in globular clusters using Newtonian dynamics"

Several star clusters show a roughly flat velocity dispersion profile at large radii, which is not predicted from self-consistent models with a tidal truncation (such as `King models'). This non-zero temperature of stars has previously been attributed to deviations from Newtonian gravity in the weak acceleration regime, but it could also be due to an additional (dark matter) component. We investigate the kinematics of stars near the edges of globular clusters assuming Newtonian dynamics and considering collisional N-body dynamics in different (tri-axial) galactic tidal fields. The flattening of the velocity dispersion can be explained by stars within the tidal radius of the cluster that have an energy slightly in excess of the critical energy of escape. Due to tri-axial shape of the Roche volume, their timescale of escape is long enough to have a measurable effect on the kinematics in the outer parts of the cluster. We derive a scaling for the velocity dispersion of these stars, as a function of clusters mass, which is remarkably close to what modified Newtonian dynamics predicts: v_rms ~ M^1/4. However, there is an additional dependence on the details of the orbit of the cluster around the galaxy centre, which can be used to discriminate between the scenarios and looked for in clusters at different galactocentric radii. Not including these stars when modelling globular cluster kinematics with equilibrium (self-consistent) models, can lead to a false detection of a dark matter halo, or misinterpretation of the underlying gravity law.

Fernández-Trincado, José Gregorio - Preparing the 6D phase-space of the Besançon Galaxy Model

We have started to prepare the Besançon Galaxy Model for the exquisite 6D phase-space data set that will be produced by the GAIA space mission. To do end, three-dimensional (3D) Galactic structures have been assembled to construct a more realistic kinematics model of the Milky Way, and have been constrained from APOGEE-DR12 and 2MASS data.

Gieles, Mark - Self-consistent lowered isothermal models (tutorial session)

We present a family of self-consistent lowered isothermal models, consisting of one or multiple mass components, with parameterised prescriptions for the energy truncation and (radial) velocity anisotropy. The models are suited to describe the phase-space density of stars in tidally limited, mass-segregated, star clusters in all phases of their life-cycle. We derive analytic solutions for the density and velocity moments in terms of potential, radial distance and model parameters. The models extend a family of isotropic, single-component models recently introduced by Gomez-Leyton and Velazquez, of which the well-known `Woolley', `King' and `Wilson' models are members. A fast Python code that solves the models is presented.

Henault-Brunet, Vincent - From “fitting models to models” to mass modelling real globular clusters

I will summarise the progress made by the "Collisional Systems” working group in assessing the validity and potential of various distribution-function based dynamical models by comparing them to mock data from collisional N-body simulations. I will then discuss our plans to move to “data space”, tackle real datasets (archival data as well as future Gaia data), and use these models to constrain the dynamical evolution of globular clusters, their mass-to-light ratio - a key quantity to check claims of IMF variations or universality -, and perhaps even the largely unconstrained retention fraction of neutron stars and black holes within these systems.

Hunt, Jason - The PRIMAL modelling code (Tutorial?)

We present a new dynamical modelling code, called PRIMAL, designed to reveal the structure of the Galactic disc from the upcoming Gaia. PRIMAL is based on the Made-to-Measure method, where a particle based galaxy model is adjusted to match observational constraints. We apply PRIMAL to mock Gaia data and show that PRIMAL can reproduce the structure and kinematics of the known target system, despite the galactic extinction and the observational errors in the mock target data. In addition, we present a population synthesis code, called SNAPDRAGONS, which can generate a Gaia-like mock star catalogue from N-body simulations, taking into account stellar populations, dust extinction and Gaia errors. We then discuss the uses of such mock data. For example, by examining Gaia mock data generated from our N-body simulation, we find that the peculiar kinematics around the co-rotating spiral arms commonly seen in N-body simulations is visible in the mock Gaia data.

Küpper, Andreas - Streakline modeling of globular cluster streams

I will review modeling methods for tidal streams, and in particular the streakline/particle spray methods, developed in the past few years

Luri, Xavier - The Gaia Status and the Gaia Archive

Mamon, Gary - The rapid Bayesian MAMPOSSt algorithm

I will describe the rapid Bayesian MAMPOSSt algorithm and describe its accuracy on estimating the dark matter density profile and velocity anisotropy of the mock GAIA-II spherical dwarf spheroidals built by Matt Walker, emphasizing how this accuracy depends on assumptions/priors and the number of observed tracers.

Penarrubia, Jorge – A new probability theory for the evolution in time-dependent potentials

I would like to present a new probability theory that describes the evolution of generic distribution functions in time-dependent potentials using dynamical invariants (constants of motion). We show that collisionless relaxation can be viewed as a special type of diffusion process in the

integral-of-motion space. In time-varying potentials with a fixed spatial symmetry the diffusion coefficients are closely related to virial quantities, such as the specific moment of inertia, the virial factor and the mean kinetic and potential energy of microcanonical particle ensembles. In potentials with a time-varying symmetry diffusion extends over multiple dimensions of the integral-of-motion space. The new theory opens up the possibility to model non-equilibrium gravitating systems using standard stochastic calculus techniques.

Miklos Peuten - Mass segregation and stellar-mass black holes in star clusters
TBC

Read, Justin - Spherical/triaxial working group

I propose to summarise the status of the spherical/triaxial working group so far and our future plans.

Romero Gomez, Mercè – Gaia detection of response spiral arms

We want to explore if the basic first order moments of the velocity distribution function in the sector of the galactic disk explored by Gaia are able to characterize the response spiral arms resulting from the evolution of the galactic bar. For this exercise we use test particle simulations and assume different values for the bar pattern speed, its inner mass distribution and the angular orientation of the Galactic bar with respect to the Sun - Galactic Centre line. A mock catalogue of Red Clump stars with astrometric accuracies expected for the second Gaia data release demonstrate that several properties can be inferred. As examples: a change in the sign of the mean radial velocity component thought the internal part of the disk is depicting the azimuth of the galactic bar; furthermore, although first order moments do not allow us to disentangle between one and two bars, changes in the spatial distribution of the first order moments obtained by changing the bar angular speed in less than 2-5 km/s can clearly distinguished.

Silverwood, Hamish - the Dark Matter density at the solar position

Determination of the Dark Matter density at the solar position is critical to direct dark matter searches. Additionally, it is important to make this determination with as few assumptions as possible, as results from direct detection searches are used to explore a wide variety of theoretical models, and hidden astrophysical assumptions could bias theoretical searches. Here we present a Jeans analysis based method for the determination of the local dark matter density which allows us to limit the number of assumptions we need to make. We fit baryon and Dark Matter density models to tracer density and velocity dispersion data via integrated Jeans equations, and from these derive the local dark matter density.

Vasiliev, Eugene - Action-based modeling

I review the current progress in construction of dynamical models using action/angle formalism. I present motivations for the use of actions as the fundamental variables, and discuss the state-of-the-art methods for transformation between position/velocity and action/angle coordinates, along with their limitations. I then present several possible applications of these methods in both theoretical and observational contexts, which could be addressed with the

software library for action-based modeling, developed by the Oxford dynamical modeling team and made available for the astrophysics community.

Watkins, Laura - Jeans models on test problems

I will discuss results obtained by running my discrete Jeans models on test problems from the Spherical and Triaxial working group. I will begin by describing tests which consider the performance of models in an ideal case with large datasets of 3-d velocities (that is, both line-of-sight velocities and proper motions). I will then discuss more realistic cases with data samples more typical of those that generally exist for dSphs.

Alice Zocchi - On the uniqueness of kinematical signatures of intermediate-mass black holes in globular clusters

Finding an intermediate-mass black hole (IMBH) in a globular cluster (GC), or proving its absence, is a crucial ingredient in our understanding of galaxy formation and evolution. The challenge is to identify a unique signature of an IMBH that cannot be accounted for by other processes. Observational claims of IMBH detection are often based on analyses of the kinematics of stars, such as a rise in the velocity dispersion profile towards the centre of the system. In this contribution we discuss the degeneracy between this IMBH signal and two other factors, namely pressure anisotropy and the presence of a population of stellar mass black holes in the GC. As an example, we analyse the case of Omega Cen by comparing the observed profiles to those calculated from a family of dynamical models that account for the presence of anisotropy and of multi-mass components in the system (Gieles & Zocchi, in preparation). We show that it is possible to partially explain the innermost shape of the projected velocity dispersion profile, even though models that do not account for an IMBH do not exhibit a cusp in the centre.