Suggestions for a bachelor theses at Lund Observatory, HT 2018

Here is the starting point for discussions with your possible supervisors.

• How did Jupiter form?

Background: This project concerns the formation of Jupiter. Gas-giant planets undergo migration when they grow inside a protoplanetary disc around a young star. The migration is mostly inwards. However, in regions of the protoplanetary disc where the temperature gradient is steep planets can also migrate outwards.

Aims: The aim of the project is to understand the growth track of Jupiter and find out if it is possible that Jupiter only underwent mild migration while it formed.

Methods: The student will write a simple code to simulate the growth and migration of Jupiter. The student will map out the parameter space in terms of the temperature structure of the protoplanetary disc, the planetary migration and the growth rate.

Supervisor: Anders Johansen (anders@astro.lu.se)

• Understanding Bayesian stellar distance and stellar parameter estimation

Background: A common approach to the determination of stellar ages, structural parameters (e.g. effective temperature) and distances, is to combine information from different surveys (spectroscopic, photometric or astrometric) in a Bayesian framework and use all of them to determine the properties of the stars together. These results are widely used to determine the properties of the star and, by extension, of the Milky Way as a whole.

Aims: The student will investigate what results we should expect, and whether they are truly unbiassed. In particular they will look at whether certain types of stars (e.g. luminous giants, stars near the main sequence turn-off) are likely to be biassed.

Methods: This study will use the Galaxia software (Sharma, 2011, ApJ, 730, 3) to create fake observations of stars, and then apply the Bayesian framework from McMillan (2018, MNRAS, 477, 5279) to analyse them.

Supervisor: Paul McMillan (paul@astro.lu.se)

• Neutron star natal kicks and gamma-ray bursts

Background: Following co-incident detection of a gamma-ray burst and a gravitational wave source emanating from a merging double neutron star binary (GW 170817), it now seems very likely that gamma-ray bursts are caused by merging neutron stars. This poses a challenge since the galactic locations of these binaries when they merge are not clearly consistent with an origin in merging double neutron star binaries.

Aims: The student will investigate the effects of supernova kicks of different strengths, and how they affect the merger locations of double neutron star binaries.

Methods: The student will determine spatial velocity distributions for neutron star binaries resulting from a given natal kick. They will then integrate orbits in model galactic potentials to indentify merger locations.

Supervisor: Ross Church (ross@astro.lu.se)

• Title: Astrometry of near field galaxies

Background: In an earlier paper Bachchan et al. (2016) showed that high-precision astrometry of galaxies at low redshifts ($z < 0.1$) potentially have interesting cosmological applications, which require the measurement of proper motions at a level of 1 μas yr^{-1} or better based on resolved galaxy images with very complex structures. This is beyond the capability of Gaia, but may be feasible with other space-based instruments.

Aims: The project will address the question of how much positional information is contained in typical galaxy images as a function of redshift, angular resolution, and number of photons collected. This can be investigated by calculating the Cramer–Rao bound of the apparent optical brightness distributions of simulated images, derived from archive images of real galaxies but degraded according to the assumed redshift and resolution.

Methods: The student will develop numerical simulations to degrade archive images of real galaxies as a function of redshift - this also requires cleaning up of background and foreground contamination of the real images. The simulations will also include a model of the telescope used to form the images at different resolutions and the simulations need to be done for a representative series of galaxies.

Supervisor: David Hobbs (david@astro.lu.se)

Ref.: R. K. Bachchan, D. Hobbs, and L. Lindegren, Gaia reference frame amid quasar variability and proper motion patterns in the data, 2016, A&A 589, A71.

• High-eccentricity entry into the Lidov--Kozai resonance

Background: The Lidov--Kozai resonance is a coupling between bodies' orbital eccentricity and inclination in a three-body system. As usually considered, it can excite a large orbital eccentricity in a system that initially has a large mutual inclination, such as a stellar triple or a planet in a binary star system.

In recent simulations of the formation of Planet Nine, Eriksson et al. (arXiv:1710.08295) found that a high-eccentricity, low-inclination planet can be caught in a Kozai resonance when a frictional force acts on the planet's orbit. In these simulations, a moderately large inclination (~20 degrees) was excited despite the planet experiencing dynamical friction from a planetesimal disc, which would be expected to damp the planet's inclination.

Aims: The student will investigate the process of entry into the Lidov--Kozai resonance through this high-eccentricity pathway. Under what conditions (strength of resonance versus strength of dynamical friction) is orbital inclination strongly excited?

Methods: This project will involve working with an analytical model of the Lidov--Kozai mechanism, and some numerical integrations.

Supervisor: Alex Mustill (alex@astro.lu.se)

• A radial star formation rate gradient in the Milky Way thick disk?

Background: Recent observations have shown that the Galactic bulge likely is composed of several stellar populations, and that a major component might be connected to the Galactic thick disk. This is evident from the very similar age and abundance trends in the metal-poor bulge and the local thick disk. However, there might be a slight offset in the position of the star formation rate (SFR) ''knee'' in the [alpha/Fe] - [Fe/H] abundance trends, indicating a slightly faster SFR in the bulge than in the local thick disk. Is this real, and if so, is there a gradual change in the ''knee'' as one from the Sun travels inwards towards the Galactic bulge?

Aims: To map the position of the ''SFR knee'' throughout the Milky Way stellar disk and in that way probe any radial SFR gradients in the thick disk.

Methods: The student will work with the new large data sets from Gaia DR2 (distances and proper motions) and cross-match them with the spectroscopic data from large surveys such as Gaia-ESO, APOGEE, GALAH, and LAMOST, that will contain elemental abundances and radial velocities for several hundred thousand stars.

Supervisor: Thomas Bensby (tbensby@astro.lu.se)

• 10 billion years of star cluster evolution within a few seconds

Background: The oldest star clusters observed in the Milky Way have formed more than 10 billion years ago, and have witnessed all phases of galaxy evolution. They can be used to infer the physical conditions at the time of their formation, and thus the physics of the very early Universe. This information being out-of-reach of observations, only simulations can provide insight. The complexity of this topic comes from the need to capture simultaneously the internal dynamics of star clusters (small scales) and the large scale effects from their host galaxies, and no existing tools efficiently include both aspects together.

Aims: The aim of the project is to develop an extremely fast code to model the evolution of clusters across cosmic time, in order to better understand what could have been their initial conditions in the early Universe.

Methods: The student will implement a simple but very fast code to model the evolution of clusters. Then, many clusters will be simulated using this code, to infer how the entire population of clusters in the Milky Way may have evolved over 10 billion years, together with their host galaxy(es).

Supervisor: Florent Renaud (florent@astro.lu.se)

Here is a list of ones performed in recent years:

Linnéa Strandell, 2017-06-16 [2017-EXA125]
The status of neutron-capture elements according to Gaia-ESO [fulltext]

Johan Appelgren, 2017-06-19 [2017-EXA124]
Can there be an Earth-like planet in HD37605? [fulltext]

Mark O Reilly, 2017-06-22 [2017-EXA118]
A study of the stellar populations in the Kepler field [fulltext]

Frida Ekstrand, 2017-06-22 [2017-EXA123]
Chemical composition of giant planet hosts [fulltext]

Mateo Prgomet, 2017-06-12 [2017-EXA126]
Assessing the Improvements GAIA-DR1 Will Bring to Dynamical Astronomy [fulltext]

Emil Zadera, 2017-06-19 [2017-EXA119]
Refining the orbits of the planets in HD 207832 [fulltext]

Rebecca Forsberg, 2017-06-09 [2017-EXA122]
Can planet formation explain the observed differences in the chemical composition of binary stars? [fulltext]

Timmy Ejdetjärn, 2017-06-19 [2017-EXA120]
Constraining the Potential of the Milky Way using Stellar Streams [fulltext]

Asma Sahli, 2017-08-15 [2017-EXA121]
Forbidden Oxygen in the Milky way disk [fulltext]

Eric Andersson, 2017-02-07 [2017-EXA109]
Fast-forward the Sedimentation of Solid Particles in Protoplanetary Disks [fulltext]

Maria Lomaeva, 2016-08-22 [2016-EXA105]
Solar system analogues among exoplanetary systems [fulltext]

Erik Dahlöf, 2016-06-30 [2016-EXA106]
Grain growth in protoplanetary discs [fulltext]

Linn Eriksson, 2016-07-14 [2016-EXA107]
The origin of Jupiter's chemical composition [fulltext]

Robert Wissing, 2016-03-01 [2016-EXA100]
Mass transfer in binary stellar systems [fulltext]

Martin Gustavsson, 2015-06-25 [2015-EXA97]
The detectability of single- and multiple-planet systems in Gaia data [fulltext]

Max Haase, 2015-06-22 [2015-EXA96]
Zinc abundances of stars in the Milky Way [fulltext]

Daniel Mikkola, 2015-06-22 [2015-EXA93]
Formation of super-Earths via pebble accretion onto planetesimals [fulltext]

Dan Wallsby, 2015-06-26 [2015-EXA94]
Doppelgänger: Two Earths in one Solar System [fulltext]

Fran Bartolic, 2015-06-26 [2015-EXA95]
The Giants and their role in Ragnarök [fulltext]

Melissa Harris, 2015-06-22 [2015-EXA98]
Hunting for Substructure in the Milky Way [fulltext]

Madeleine Burheim, 2014-12-03 [2014-EXA88]
Relative Astrometry and Orbit Determination (Hobbs) [fulltext]

Tobias Arvidsson, 2014-06-30 [2014-EXA83]
The Survival of Stellar clusters (Church) [fulltext]

Joakim Eriksson, 2014-07-04 [2014-EXA87]
Migrating dust particles (Johansen) [fulltext]

Brian Thorsbro, 2014-09-09 [2014-EXA84]
A kinematic check of the distance scale of galactic cepheids (Lindegran) [fulltext]

Edvin Zigmanovic, 2014-09-09 [2014-EXA91]
Dark Matter subhalos gravitational dynamics and evolution (Pasechnik) [fulltext]

Henrik Nordanger, 2014-07-04 [2014-EXA85]
The stability and habitability of exomoons (Davies) [fulltext]

Johannes Gebhard, 2014-06-10 [2014-EXA]
Numerical simulations of magnetorotational turbulence with hyperdiffusivites (Johansen/Yang) [fulltext]

Joel Wallenius, 2012-01-20 [2012-EXA59]
Unearthing exoplanets (Hobbs) [fulltext]

Adriaan-Alexander Ludl, 2011-09-07 [2011-EXA58]
Astrometric Detection of Gravitational Light Deflection by Jupiter with Gaia Data (Hobbs, Magisterexamen) [fulltext]

Adriaan-Alexander Ludl, 2011-09-07 [2011-EXA57]
Investigating Mono- and Quadrupole Gravitational Light Deflection by Jupiter (Hobbs) [fulltext]

Petter Thorén, 2011-08-17 [2011-EXA56]
Identifying Moving Groups Using Elemental Abundances (Feltzing) [fulltext]

Clément Bonnerot, 2011-08-25 [2011-EXA55]
The Dynamical Evolution of Young clusters With a focus on the effects on planetary systems (Davies) [fulltext]

David Lundberg, 2011-07-05 [2011-EXA54]
Natal kicks in Double Neutron Star Binaries (Church) [fulltext]

Ellinor Andersson, 2011-06-08 [2011-EXA53]
Spectral analysis of Ca I (Nilsson) [fulltext]

Serena Repetto, 2011-04-27 [2011-EXA52]
Investigating Black Hole Kicks (Davies, Magister) [fulltext]

Viktor Holmelin, 2011-03-08 [2011-EXA49]
Constraints on planetary orbital evolution theories from detection of multiple transits (Johansen) [fulltext]

Angelica Brolin, 2010-09-08 [2010-EXA47]
Excitation processes in low pressure plasmas (Huldt) [fulltext]

Kristina Doxsee, 2010-09-07 [2010-EXA46]
Inquires into the absence of extended globular clusters in the Milky Way Galaxy (Davies) [fulltext]

Fredric Ericson, 2010-09-01 [2010-EXA45]
Specroscopic Analysis of Neutral Gallium (GA I) (Nilsson) [fulltext]

Mohsen Farzone, 2010-06-30 [2010-EXA44]
Examining the population of free floating planets (Davies) [fulltext]

Karl W. Jansson, 2010-06-29 [2010-EXA43]
On the origin of hypervelocity stars (Davies) [fulltext]