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Statement of Research Interests

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For the position:
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An astronomer by night and a software developer by day, my research interests are split between these fields. In the following two sections I present my long term goals.

A community developed generalised instrument simulation tool

One does not simply walk on the moon. Every possible scenario had been simulated prior to the astronauts ever seeing the rockets that would carry them aloft. While the consequences of failed astronomical observations are not nearly as drastic as a failed mission to the moon, telescope time is becoming ever more precious. An hour of ELT time will cost the equivalent of ~40k€ and observing time pressure will be extremely high. Hence failed observations are simply unacceptable. As the astronomical community gains access to larger and more complex telescope systems, the need for simulating observations prior to applying for telescope time will increase drastically. **Unfortunately the software landscape for observation simulators accessible to the general community is despairingly empty. It is my long term goal to change this.**

Just as the astropy project became an indispensable tool to the community by unifying many disparate but essential code bases under one package, so too would I like to create an open source community developed platform for simulating data from any current and future instrument. My current work on the MICADO and METIS instrument simulator has given me the background knowledge needed to achieve this goal, and my duties as leader of the ELT community working group on instrument simulators provides the perfect platform from which to launch this project.

Skeptical voices have already been quick to point out that I am not the first to attempt this. What has been missing from previous efforts though, is a modular, yet holistic approach to simulating the observations. By this I mean that while every telescope system is different, there are many common elements that can be stacked together like lego bricks to create models of an optical train. By separating the instrument descriptions from the code as well as providing templates for the user to describe their desired on-sky object, I am very confident that we can write a code base capable of simulating most, if not all, telescopes and instruments in use today. A general schematic for how a generic simulation landscape would look can be found here: https://sketchboard.me/ZBKGPsSQHnFh#/.

It is almost impossible for a single person or team to write and test all possible combinations of optical effects. However by involving the community we can benefit from both the expertise and coding ability of several generations of instrument builders that is otherwise going unleveraged.

As far as further funding is concerned, I see multiple Austrian avenues via FFG and/or FWF projects. The scope of the project however also fits perfectly into international funding programs like the Google “Summer of Code” program.

A source catalogue for solving the question of IMF universality

The initial mass function (IMF) is a fundamental parameter in many areas of astrophysics, yet it is still described by an empirically derived, and apparently environment-independent function. What inhibits a better understanding is the fact that the only true way to determine the IMF for a region is to count all the stars. In the majority of young star forming regions both the resolution and sensitivity of current instruments limit the success of most studies of the IMF.

With the ELT this will all change (see Leschinski and Alves, 2020). The ELT’s unprecedented resolution and sensitivity will allow all stars to be detected in almost all Milky Way and Magellanic young stellar clusters. Studies of the IMF will move from speculating on deviations to quantifying environmental dependencies in a statistically relevant manner.

MICADO and the ELT will only come online in the latter part of this decade. In the meantime there is plenty of preparatory work to be done. **My long term goal is to find the most optimised list of targets that will enable a robust statistical investigation of the environmental factors that do and do not affect the shape of the IMF**.

To achieve this I plan to:

- simulate observations of a large portion of the known Milky Way and Magellanic young stellar clusters using models based on their known internal and external properties for a series of standard mass functions,
- using standard techniques, determine the level of accuracy that ELT observations should provide with respect to a cluster’s IMF shape,
- determine how many clusters are needed to statistically sample the environmental parameter space, incl. metalicity, interstellar radiation field, gravitational potential, etc.,
- compile a list of known clusters that will enable the most efficient coverage of this parameter space in terms of telescope time.

Given the sheer power of the ELT and the importance of the IMF in astrophysics, finding the answer to the question of IMF universality provides an easily attainable, yet very high impact result for the community. Through generating this catalogue, which will hopefully serve as a road-map for global statistical studies of the IMF, I hope to play a small yet significant role in the discoveries to come.