1. What’s the problem?

It is becoming clear that the striking difference between ellipticals and spiral galaxies is actually a result of variation in the relative prominence of their more fundamental spheroid and disc components (see Fig.1). Our understanding of galaxies would therefore be greatly improved by considering these physical components separately. However, measuring the properties of the individual components within a galaxy is considerably more difficult than measuring its overall properties as done by fitting codes in their current versions.

Current fitting routines only use a small fraction of the available data (e.g. one band in a multi-band survey). Several independent fits on all bands do not overcome this problem, simultaneous usage of all band and multi-component fitting is required. More, current 1-band-1-components fitting results are dependent on the chosen wavelength for the fit (see Fig.2) due to the mixing of the light of 2 separate galaxy components that dominate different regions of the galaxy image, e.g. a red bulge in the center and a blue disc in the outskirts.

Reliable Bulge/Disk decomposition on one-band data, as currently, being carried out by some groups, is challenging because of parameter degeneracies and multiple minima in likelihood space. Additional emission from AGN could cause some of these minima and make the fit move stable and physically meaningful, e.g. by effectively allowing the code to fit a red stellar population in the red bands and extrapolating to blue bands and vice versa.

The MEGAMORPH project, a collaboration between astronomers, statisticians and computer scientists funded by the Qatar National Research Fund, is tackling this problem by utilising the full set of multi-color information available for each galaxy and so potentially is able to separate different stellar populations within a galaxy and derive physically-meaningful structural parameters.

2. Where did we start?

We have both GALFIT (Galaxy fitting in General Analytical Framework) and GALAPAGOS (GALaxy fitting and Parameter Analysis for GALaxies) at the ready as well as ALAPFIT (ALAPAGOS - automated Multi-band fitting of galaxy profiles) and ALFIT (ALAPAGOS - automated Multi-band fitting of galaxy profiles). GALFIT, two pieces of established and well tested software, which we adapt to perform robust, physically meaningful, galaxy bulge-disc decompositions for a large sample of galaxies. We will also adapt the code to be used on high-performance computing facilities, to allow it to run on surveys with millions of galaxies.

3. Where are we now?

The MEGAMORPH project is still very much in development but we have already added some new features to the codes used. We have:

• selected the baseline system used throughout the project: GALFIT, ALAPAGOS and GALAPAGOS (see Fig.2)
• selected and created the test environment, using:
  • simulated survey data (Following Hauessler et al.,2007).
  • real survey data (CAMA, Driver et al., 2010)
• artificially redshifted real galaxies (using FERENGI),
• speed up the code in critical places and nearly halved the CPU time needed to run on real data.
• have adapted GALAPAGOS to use variable PSFs, depending on objects position. This is important for ground-based surveys.
• adapted both GALFIT and GALAPAGOS to be able to use multi-wavelength data simultaneously.

We have successfully run GALFIT on the codes on a small subregiment of the GAMA survey with around 10000 galaxies. One of the fits is shown in Fig. 4. In this run, the shape of a single spheric profile was held fixed and changes were made to the sizes and asymmetry (with constant freedom) from band to band. As one can see, the fitting magnitudes are in better agreement with photometric data than single-band fits. By design, the size was held fixed in this run. This is a user chosen specification, the code offers full flexibility on each parameter individually.

On a different approach, we have successfully redshifted a sample of 100 local galaxies to redshifts out to z=0.25. We are in the process of fitting these images using a similar automated technique to be able to:

• evaluate the current fitting and redshifting and the bias introduced into real survey data by this fit.
• test the robustness of our codes now and in the further-development.

Fig.5 shows an example of this redshifting and fitting procedure.

4. Where are we going?

The aim of the project, and, beyond the general distinction between spheroids and discs, they display a range of higher level features that make it difficult for computational methods to extract meaningful information. To overcome this problem, we want to introduce non-parametric components into the fit to be able to successfully subtract components like faint spiral arms or star forming regions from the data fitting the only fit the underlying profile. The next step is the introduction of a second fitting component, effectively moving from single profile fitting to full Bulge-Disk-Decomposition. Multi-wavelength data and fitting should be able to overcome many of the degeneracy problems that current, 1-band, B/D compositions have, due to its power of using the full colour information of an image galaxy on a pixel by pixel basis. An accurate best-model-selection has to be installed to automatically choose which fit resembles the galaxy profile more accurately.

To control the computational intensity of the task, we will need to use efficient algorithms and tools to optimally use the full CPU available. We are still trying to speed up the actual code, but will also adapt it to work on high-performance computer facilities either on local HPC machines available to the user or e.g. Amazon Web Services.

After final testing and demonstration, we will publish the code for everyone to use on their dataset and in their own setup.