

Scientific Report: A Cosmic Census of the Galaxy Populations in the Distant Universe

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Description and aims

Understanding the evolution of galaxies across cosmic time is one of the great challenges of astrophysics. Current observations and theories have significant uncertainties in e.g. the feedback processes that influence star formation and the way in which the demographics of galaxy populations and their evolution depend on their environments. To make progress, we need to map well-defined samples of galaxies in statistically representative range of environments using telescopes that probe different physical processes. These observations provide statistical constraints on models of galaxy formation in which the star-formation, stellar mass and accretion activity in galaxies of galaxies are tied to the history of the dark matter halos in which they reside. Rare populations of galaxies also provide sensitive tests of the extremes of such models.

To address these topics many ambitious survey programs (covering a few, tens, hundreds or thousands plus square degrees) have recently been carried out, or are currently underway, at the major astronomical observatories, e.g. VISTA, LOFAR, Herschel etc. The Herschel Extragalactic Legacy Project (HELP), funded by the European Commission Research Executive Agency, aims to "help" by bringing together these various projects.

The foundation of HELP is 1300 deg² of data from the European Space Agency's (ESA) Herschel space mission. Exploration of the star formation history of the universe, using extragalactic surveys, was a major goal of the Herschel mission. By combining the data from many observatories, utilizing advanced statistical techniques and developing new tools HELP intends to overcome the limits of Herschel resolution and enable astronomers in Europe to realize Herschel's full potential.

HELP will create a multi-wavelength, homogenous, photometric resource covering ~1300 deg², with added-value in the form of photometric redshifts and physical modeling of e.g. stellar mass, dust masses and star-formation rates.

Our workshop was timed for the midpoint of the HELP project. It brought together for the first time the European scientists who were expected to be key beneficiaries of HELP, with members of the international multi-wavelength survey teams (including LOFAR) and the core HELP team. Through direct interaction between the HELP team and the users, the science exploitation was able to begin in earnest. HELP could also get feedback and make adjustments to future direction of project, so that final data products and tools have the greatest legacy value possible. Furthermore, the key tools and data products enabling European astronomers to understand the growth of galaxies across the history of the Universe would be provided.

The key objectives were to:

- Explore the scientific questions that these multi-wavelength datasets seek to address;
- Review the available, ongoing and planned datasets and assess the needs for new observations;
- Assess the progress on the technical challenges e.g. in photometric redshifts, dealing with selection functions and resolving the Herschel confusion challenge;
- Compare and assess the methods for modelling the intrinsic physical properties of galaxies from their observed photometric properties;
- Critically assess the tools and delivery of data to best meet the needs of the community in addressing the scientific questions.

Organization and format

The workshop exploited different formats. There were some standard review/invited level talks, a few shorter contributed talks, moderated discussion and breakout sessions and “hack sessions” with demonstrations of software tools and short tasks and a final “hack day” where participants tried to achieve their own objectives using tools provided.

The moderated discussion sessions and breakout sessions were extremely valuable. There was lots of very active and healthy discussion on many different topics and issues were raised, thrashed about and plans formed.

The hack sessions/hack days were a new concept for many participants and relatively new for the organisers. They were useful in introducing participants to the new software. However, they were not as successful as we’d hoped. We think they have great potential but in future we believe the participants need to be given more information in advance of the meeting to be better prepared and we need more trained facilitators to get people working more quickly.

The review talks were very useful to get everyone “on the same page”. There were probably too many review talks and we could have removed the contributed talks to give more space for discussion and working sessions.

Scientific developments

This meeting brought together extragalactic astronomers studying galaxy evolution using surveys with many telescopes. It was lead from the Herschel Extragalactic Legacy Project (HELP) and was intended to share with the wider community what that project was doing, to learn from the community what the priorities should be and to develop collaborations to take this forward.

We had breakout sessions on: galaxy environments, high redshift galaxies, galaxy lensing systems, population modelling, photometry, photometric redshifts, galaxy quenching, spectral energy distributions modelling, star formation and AGN connections, luminosity functions and Bayesian statistical methodologies.

Various new data sets were released to the participants during the meeting, including the COSMOS data, new Herschel HerMES and HATLAS data and Herschel photometry in COSMOS field using the new HELP xid+ methods.

Highlights included the discussions on: database visualisation, photometric modelling methods, Active Galactic Nuclei (AGN), and luminosity functions and clustering. The visualisation discussions explored how the complex data in these fields could be represented to users, and clearly articulated a challenge, if not yet the solution! The discussions on photometric modelling methods introduced different teams to each other approaches and clarified the differences, new ways forward were discussed and collaborations appeared to be emerging. The challenge of AGN in these multiwavelength data sets was recognised and collaborations formed to help address these within HELP. A strong group formed around the topic of exploiting the HELP data to understand luminosity functions and clustering and this group have been meeting to discuss this topic since.