

RESEARCH CONFERENCES

ESF-FWF Conference in Partnership with LFUI

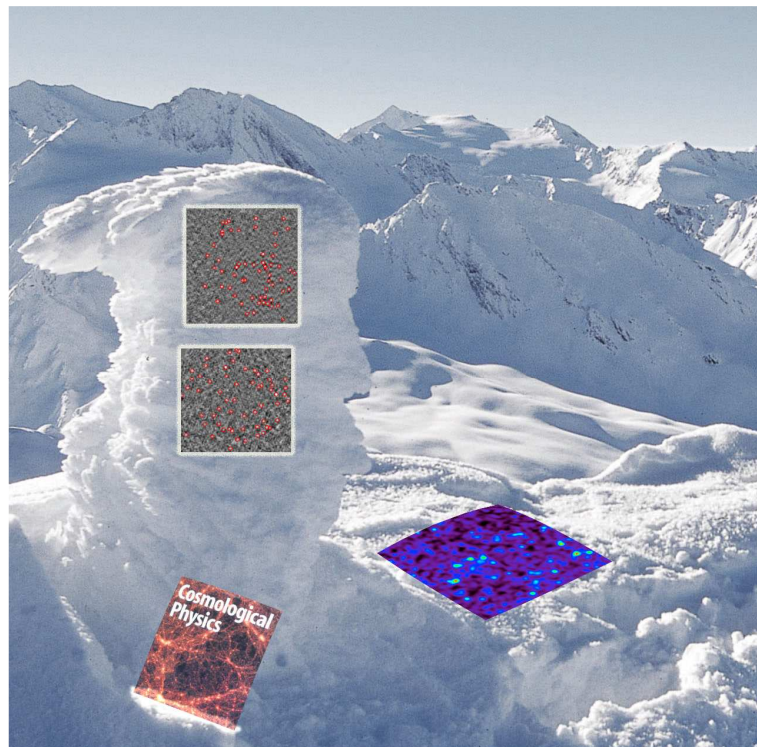
The Origin of Galaxies: Lessons from the Distant Universe

Universitätszentrum Obergurgl (Ötz Valley, near Innsbruck) • Austria
12-17 December 2009

Chair: Eelco van Kampen, LFUI, Innsbruck, AT

Co-Chairs: Jim Dunlop and John Peacock, University of
Edinburgh, UK

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Conference Highlights

Please provide a brief summary of the conference and its highlights in non-specialist terms (especially for highly technical subjects) for communication and publicity purposes. (ca. 400-500 words)

The conference brought together observers and theorists working on galaxy formation and evolution, with the emphasis on the distant universe, where galaxy formation can be observed 'in action'. The meeting was a follow-up to the first in this series in two, where the emphasis was on preparation of observations with three main new facilities: Herschel, SCUBA-2 on the JCMT, and the Atacama Large Millimeter Array (ALMA). Only the first one started taking data in 2009 (SCUBA-2 will start in 2010, ALMA in 2011), and the first results from some of the major Herschel surveys provided one of the highlights of the conference.

However, various other instruments produced truly interesting results as well, including BLAST, the SPT, Spitzer, and both the old and new cameras on the Hubble Space Telescope. All these were presented at the meeting, with most attention to the extensive analyses performed on the BLAST data. Almost the whole wavelength range was covered, although many presentations focussed on the far-infrared to mm part of the spectrum, as this is where many new instruments became available, providing a large potential for new discoveries by opening up this window.

The research field is dominated by surveys, at the moment, in many wavebands, and this also dominated the meeting. The largest surveys are done for galaxies in the nearby universe, whereas at high-redshifts sample size are slowly increasing, but not to the stage where population statistics become feasible. However, it became clear from the meeting that this will be possible in the near future, up to redshifts $z \sim 7$ or so. The nearby surveys produce large databases of galaxies, in many wavebands, so population statistics are almost easy there. However, follow-up of 'interesting' sources is something that is starting only now, and the meeting provided a good opportunity to plan such follow-up observing programs.

X I hereby authorize ESF – and the conference partners to use the information contained in the above section on 'Conference Highlights' in their communication on the scheme.

Scientific Report

Executive Summary

(2 pages max)

This conference was the second in a series of two meetings, and the logical follow-up of the first one. A fair fraction of the participants of this second meeting also took part in the first one, but we did also attract many new participants, most notably PhD students who recently entered the field of galaxy formation and saw this meeting as an excellent opportunity to get an overview of where we are and what the near future is going to bring.

In the end we (John Peacock, Jim Dunlop and myself) were able to attract an excellent set of active researchers in the field of galaxy formation, with a good spread in nationalities, gender, and area of research. This resulted in a diverse and rich programme, with renowned speakers as well as PhD students in the later stages of their project. The level of the talks turned out to be outstanding, and there was a great deal of discussion. These discussions were usually continued in the bar/restaurant area, which is one of the great benefits of the conference centre. All presentation have been collected during and after the meeting, and have now been posted on a website (<http://www.eso.org/~evkampen/Obergurql09/Talks/>).

An important aspect of the conference was to bring together people from various continents that are involved in large (and expensive !) surveys which are sometimes complimentary, but more often overlapping. This provides many opportunities for multi-wavelength studies of the high-z galaxy population, and this meeting helped bring together researchers from these different surveys. Furthermore, the first meeting in this series, the 2007 conference, was very useful in planning the various surveys that are now ongoing, whereas this second meeting helped to re-assess these plans in the light of the first results, and new theoretical insights. Also, surveys which have not started yet, because instrument development has been delayed, could adapt their strategies, and some of that took place at this meeting.

Besides the major surveys, there were quite a few gems among the results of the smaller observational projects presented, and the theoretical talks provided the necessary input to make sense of these results. Within the next 5 years progress in numerical techniques and computational hardware should match the expected progress in resolution and sensitivity offered by ALMA and the EVLA, and eventually the E-ELT and SKA. This synergy between theoretical and observational progress was nicely illustrated.

Scientific Content of the Conference

(1 page min.)

- Summary of the conference sessions focusing on the scientific highlights
- Assessment of the results and their potential impact on future research or applications

In the following I will list highlights for each of the sessions, which constitutes a somewhat personal selection of what was presented. I've listed the speakers that touched on these topics, or actually presented the particular highlight.

Session 1:

- there are two ways to interpret galaxy data: numerical simulations involving gas dynamics (SPH, GRID), and semi-analytic models (SAM). Both use stellar population modeling to match masses, colors, dust (talks by Tonini, Henriques, Silva, and Mentuch). Also demonstrated: the complementarity of SPH and AMR simulations
- claimed successes: cosmic SFH, local TF relation, morphologies of $z \sim 3$ galaxies, origin of SMGs, AGN feedback (Moore, Nagamine, Gonzalez, Somerville, Narayanan)
- controversies: "AGN feedback overstressed in semi-analytic models" (from hydro simulations) "semi-analytical models need top heavy IMF to explain SMG counts"

Session 2:

- Growing body of data at $1 < z < 3$: formative period in galaxy evolution (le Fevre, Ilbert, Mannucci)
- formation of the red sequence at $z \sim 0$ (Faber and Hudson)
- integral field spectroscopy at $1 < z < 1.5$ (Vergani)
- mass-metallicity relation at $z \sim 3$ (Mannucci)
- 'quenching' of central galaxies, a 'star-forming band' in the $M_{\text{halo}} - z$ plane (Faber)

Session 3 and 4:

- a possible rapid drop in Ly-alpha emitters from $z=5.7$ to $z=6.6$ (Ouchi)
- the first deep field with Hubble's new WFC3 camera (McLure, Bouwens, Grazian)

Session 5 and 6:

- expanded & updated catalog of sub-mm galaxies with spectroscopic redshifts (Chapma, Casey)
- evidence that sub-millimeter galaxies are dissipative gas-rich mergers (Tacconi, Walter)
- evidence for low-metallicity gas in high- z radio-selected sub-mm galaxies (Chapman)
- new clustering measures of sub-mm galaxies from various samples (Viera and others)
- additional measurements for the cosmic star formation history (Halpern and others)
- first results from two major Herschel surveys: HERMES (talk by Oliver) and H-ATLAS (Clements)

Session 7 was the forward-look (future) session: see next section of this report

There was a good response to the results presented (all talks were delivered very well !), with ample discussion, which often caused the sessions to overrun a little. The most lively session was session 3, where competing teams analysed the same datasets (the deep field from Hubble's WFC3), where the ultra-high redshift galaxy population is starting to be studied in some detail. A large fraction of the conference was dedicated to longer wavelengths, as there is a lot of activity in that wavelength regime, with many new instruments that just became available, or will become available shortly. A similarly large fraction of future research in galaxy formation will therefore be concentrated in this wavelength range, and this conference provided a very interesting glimpse of things to appear in the next two years.

Forward Look

(1 page min.)

- *Assessment of the results*
- *Contribution to the future direction of the field – identification of issues in the 5-10 years & timeframe*
- *Identification of emerging topics*

The last session of the conference, Session 7, included a review by the well-known astronomer Richard Ellis from Caltech, who did an excellent job reviewing all results presented at the conference, and putting them into perspective. However, in this session we also heard about and discussed future instruments and theoretical efforts. Most notable were the large up-coming observatories: ALMA, SKA, JWST, E-ELT, and the TMT. These are large and expensive new instruments that sometimes make people think that smaller instruments are no longer considered useful, but this was nicely demonstrated not to be the case in the last regular talk before the review, on the GISMO detector. However, it is probably true that most researchers are getting into shape to exploit the new large instruments, as well as the existing ones (an example was given for Spitzer by Kai Noeske).

The future direction of the field is likely to be determined by these new large instruments, with correspondingly large collaborations. This means that it is important to make these large collaborations work well, and management is getting an ever more important role in astronomical research. This is an issue that is sometimes ignored, and a body like the ESF might help there.

Over the next 5 years the far-infrared to mm wavebands will dominate the observational research in galaxy formation, through Herschel, SCUBA2, ALMA, and the LMT, amongst others. On a longer timescale, in about 10 years or so, the new large optical observatories will appear, along with the infrared-optimized JWST. On a somewhat larger timescale the SKA will allow major progress in the radio part of the spectrum, preceded by the SKA pathfinder experiments Meerkat and ASKAP.

All these new instruments will need to be exploited efficiently, and this is another area where the ESF could contribute with research networks and research conferences, as well as providing funding for researchers to make the most of these instruments scientifically. And of course the theoretical efforts should not be forgotten, as all these results need to be interpreted and put into context. Numerical astrophysics should be a major contributor there, and the exploitation of state-of-the-art supercomputer centres in Europe should be a priority. Also, simplified access to these facilities should be made possible, an effort in which the NSF is taking a lead at the moment.

Within the field of galaxy formation, the emerging topics are mostly related to the physical processes at high-redshifts, which are more often than not different from what we see in the nearby universe. AGN feedback and cold flows are now hot topics, but the new instruments will allow other topics to be studied, most notably molecular physics. The interplay between the various molecules (for example CO, C+, and HCN) and the other, better-known components will be one emerging topic. Spectroscopy at high redshift will be another. Finally, multi-wavelength studies are now common in the nearby universe, but will – over the next ten years – also be established at high redshifts.

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- *Is there a need for a foresight-type initiative?*

Not yet, as many surveys have just started, but this might become an interesting option in about 2 years time, when the first survey results will appear and a new direction (follow-up ? more data ? different data ? more effort in theory ?) might be appropriate, or even necessary.

Atmosphère and Infrastructure

▪ *The reaction of the participants to the location and the organization, including networking, and any other relevant comments*

The feedback I received personally (independent from the poll conducted during the meeting) was very positive, and very satisfying for me as one of the organizers of the meeting. This was not the first meeting I organized in Obergurgl, so I noticed that the infrastructure is getting even better over the years. It really is a smoothly running conference centre, with everything needed in place. Of course the nice weather helped, but the centre can be congratulated on their operations in any case.

A few reactions from the participants:

“You should know that nearly everyone I've talked to agrees that this was one of the best meetings in years on galaxies. Very inspirational.”

“Thanks a lot for hosting such a wonderful conference! I really learned quite a bit and very much enjoyed my time in Obergurgl. I do hope this happens again in 2 more years!”