and spectroscopic surveys identifying the first galaxies, rare quasars, supernovae and gamma-ray bursts.

A lively discussion arose on data policy and data mining for surveys and ELTs. Most participants agreed that proprietary time should be at the minimum level but sufficient to guarantee intellectual ownership and a satisfactory progress of the surveys and the ELTs. Others proposed to have the data public from the beginning. In order to facilitate data mining, it was proposed that all data provided by the surveys and the ELTs should be Virtual Observatory compliant from the outset. Another interesting discussion was about ELTs sharing their development efforts through common documentation, complementary instrumentation capabilities, sharing information on site monitoring and sharing observing time.

The third part of the discussion dealt with how to retain diversity and how to involve young people in the era of flagship projects. Astronomers agreed that a large fraction of open time should be available at the ELTs, together with encouraging some explicitly high-risk projects. It was noted that is very important to retain a broad range of facilities, including 4-metre- and 8-metre-class telescopes, to be used as survey facilities, to promote small projects, and to train young astronomers. All the long-term flagship projects should try to involve more students and young researchers, allowing them to attend science working committees, and communicating the outcome of the major high-level decisional meetings to them. Furthermore, it was proposed that at least one young astronomer should be included in each of the ELT science committees. More resources should be allocated to provide for longer term contracts to leave young astronomers more time to develop new and creative ideas.

Richard Ellis, in summarising the conference, highlighted the opportunity to establish a better coordination of facilities, instrumentations and programmes and that we should further strengthen these collaborations in the future. He also emphasised the power of emerging countries and public outreach for investments in astronomical research and that diversity in facilities and astronomical capabilities should be retained together with large-scale projects. Ellis reminded us that we cannot plan the future in detail and so optimism, versatility and creativity remain the key attributes for success.

All the presentations and the conference picture are available at the conference website: http://www.eso.org/sci/meetings/2011/feedgiant.

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Links

[1] More about the World Café format at: http://www.theworldcafe.com/

Report on the ESO/MPE/MPA/ExcellenceCluster/LMU Joint Astronomy Workshop

The Formation and Early Evolution of Very Low-mass Stars and Brown Dwarfs

held at ESO Headquarters, Garching, Germany, 11–14 October 2011

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The topics discussed at the workshop ranged from the structure and fragmentation of molecular clouds to the formation of individual very low-mass objects, their multiplicity, physical structure, mass distribution and early evolution. Each topic was introduced by two reviews on the status of our theoretical and observational understanding of the field, followed by presentations of new results and discussions. In this report we provide a brief summary of some of the areas discussed at the workshop.

Very low-mass (VLM) stars (< 0.4 $M_{\odot}$) and brown dwarfs (BDs) are faint objects with low effective temperatures which are difficult to detect due to their low luminosities ($\lesssim$ 0.01 $L_{\odot}$). On the other hand, these objects are the major constituents of the stellar population of any galaxy and outnumber higher-mass stars by factors of hundreds to thousands. Current wide area surveys in nearby molecular clouds, from optical to far-infrared wavelengths, provide exciting new information on the process of the formation and early evolution of VLM stars and BDs. We report on the ESO/MPE/MPA/LMU/ExcellenceCluster joint workshop dedicated to recent theoretical and observational advances made in the field of study of the formation and early evolution of brown dwarfs and very low-mass stars.

It was demonstrated in several talks that, with the help of new and powerful ground- and space-based facilities (e.g., VISTA and Herschel respectively), we are starting to discover young VLM stars and BDs and their precursors in numbers large enough to allow statistical analyses of their properties. In addition, detailed studies of individual objects and small samples are now effectively being

carried out with large optical/infrared telescopes and millimetre arrays (e.g., VLT/X-shooter and ALMA). On the theoretical side, the latest modelling results were discussed and confronted with the observations. Approximately 120 participants came together in Garching (see Figure 1) for lively discussions in five sessions on the dedicated topics summarised below.

Structure of molecular clouds: Formation and properties of cores

Substantial progress in understanding the formation of pre-stellar cores has been made thanks to the Gould Belt survey of nearby molecular clouds performed with the Herschel Space Observatory. The emerging picture is of the important role of filaments as the prime places for pre-stellar core formation (review talks by P. Myers and P. Andre). The typical structure of a filament, based on the analysis of more than 100 filaments in different molecular clouds, is that of a narrow, steep density profile with a characteristic width of roughly 0.1 parsecs. Observational evidence was presented for the formation of a pre-stellar core from velocity-coherent gas flows along the filament directions (talk by A. Hacar). It was further argued that pre-stellar cores are formed from the fragmentation of the densest parts of the filaments and that filament fragmentation forms the basis of the (sub)stellar initial mass function by setting the mass distribution of pre-stellar cores. It was also shown that Herschel observations of the Perseus and Serpens clouds suggest that the spatial density distribution of pre-stellar cores is scale-free, a result consistent with the spatial density distribution of young stellar objects in nearby molecular clouds (talk by E. Bressert). These findings support the ideas of the existence of a column density threshold for the formation of cores and stars and that the global properties of the outcome of the star formation process in nearby clouds is closely linked to the fragmentation process of molecular clouds.

However, the unambiguous identification of the precursors of BDs and VLM stars remains elusive: very low luminosity pre-stellar cores remain undetected; and low luminosity Class 0 sources with $L \lesssim 0.8\ L_{\odot}$ appear under-abundant in a large survey of protostars in the Orion star-forming region (talk by W. Fischer).

Figure 1. Group picture of the workshop participants in the entrance hall of ESO Headquarters.

From cores to stellar systems: Fragmentation, properties and multiplicity of protostars

In this session several models for the formation of VLM stars and BDs were reviewed and discussed by M. Bate, A. Boss, S. Basu and D. Stamatellos. New numerical simulations, including radiative feedback from protostars, show reduced core fragmentation and produce much fewer BDs than in previous simulations. Very low-mass stars and BDs may also be formed in fragmenting massive circumstellar discs involving subsequent ejections from these discs. Ejections are frequent events and may happen even at early evolutionary stages, leading to ejected low-mass clumps. However, it was pointed out that massive discs around Class 0 sources are not observed and that radiative feedback tends to inhibit disc fragmentation. This problem could be overcome if radiative feedback is episodic, with long periods of quiescence. The detection and physical characterisation of very low luminosity objects (VeLLOs) remains an observational challenge, but a few candidates were presented (in talks by M. Dunham and T. Huard). Progress in this respect is expected to be made soon with ALMA, which provides excellent sensitivities at submillimetre wavelengths and at high spatial resolution.

The observed properties of low-mass protostars/proto brown dwarfs are clearly a key to understanding their formation. Protostellar/brown dwarf multiplicity was discussed by several speakers (G. Duchene, A. Kraus, P. Viana Almeida and R. Parker). It has been established over the last couple of years that the binary frequency declines with primary mass, a trend that continues down into the substellar regime. For the youngest objects, it seems that there is a lack of 100–500 AU separation Class I binaries (not specific to a particular primary mass range), while a high fraction is observed at larger separations. Also, Class 0 objects show a low binary frequency at separations < 2000 astronomical units (AU).

Revealing and understanding the low-mass end of the stellar initial mass function

The third session was introduced by a critical review from G. Chabrier of different theoretical scenarios of VLM star and BD formation and the confrontation with recent observations of the initial mass function (IMF). The large number of accumulating observational studies targeting the IMF in various star-forming regions was then summarised in a second review talk by K. Luhman, suggesting that the low-mass IMF shows in general very little, if any, variation. On the other hand, the measured IMF is subject to substantial biases as a consequence of different observational approaches, such as the use of different stellar evolutionary models to convert the observed magnitudes to (sub)stellar masses, different spectral classification schema, or the restriction of the analysis to photometric data alone.

Several observational results based on recently completed or ongoing wide-field imaging surveys, such as UKIDSS/GCS or VISTA/Orion, in various star-forming regions showed the detection of numerous candidate VLM objects impressively, down to the lowest-mass T-type dwarfs (talks by N. Deacon, N. Lodieu, C. Alves de Oliveira, K. Muzic and J. J. Downes). Evidence was presented that shows no difference in the spatial distribution of stars, VLM stars, BDs and planetary-mass objects (talks by A. Bayo, K. Pena Ramirez). The typical ratio of low-mass stars to brown dwarfs is 4–5 (P. Dawson) with some scatter from one star-forming region to another. However, the explicit shape of the substellar IMF is still under discussion. During the workshop the essential concern was raised that the faintest (i.e. usually the lowest mass) objects detected in most of the surveys (< 13 M_{Jup}) are only photometric candidates, and spectroscopic follow-up is urgently required. It was also pointed out by various speakers that the true (low-mass) end of the IMF has not yet been found.

The circum(sub)stellar environment: Discs, outflows and accretion processes

The large body of evidence for a "T Tauri-like" phase in the early evolution of VLM stars and BDs was emphasised in many talks (e.g., by L. Hartman and A. Natta). Recent studies also suggest outflow, accretion variability and disc properties similar to those of more massive pre-main sequence stars. These findings, although generally consistent with the idea that objects as low as ~ 50 M_{Jup} can form in a similar fashion to more massive stars, cannot yet rule out different formation channels (ejection from multiple systems or fragmenting discs) starting to play a more significant role in the low-mass and brown dwarf regimes.

The key role of high sensitivity and simultaneous broadband spectroscopy with instruments like X-shooter at the VLT was pointed out as an important step to understanding the complex interplay between discs, accretion and outflow in these objects (talk by J. M. Alcalá). The statistical analysis of the accretion signatures in large population studies is starting to show evidence for different timescales depending on the mass of the central stars (talks by A. Natta and C. F. Manara). The intriguing discovery of a population of very long-lived accretors in the regions around very massive clusters in the Magellanic Clouds and in the inner regions of the Galaxy was also presented (talk by G. De Marchi).

Figure 2. Stamp depicting a young brown dwarf with an outflow, issued by the Republic of Ireland Post to celebrate the International Year of Astronomy in 2009, was shown several times at the meeting.

Sensitive surveys seem to suggest that circumstellar discs around VLM stars and BDs are at least as common as in T Tauri stars, and their properties appear to be similar (talks by S. Mohanty, D. Jaffe and M. Gully Santiago). The current millimetre observations do not yet allow us to resolve the disc sizes and place strong constraints on the ejection models, but it is expected that ALMA will soon allow these constraints to be lifted. Brown dwarf discs are also an interesting case study to test disc evolution theories in a very low density regime. In particular, probing grain growth in very low-mass discs, such as those found around BDs, will allow us to put strong constraints on dust evolution models. The rapid and ubiquitous dust grain evolution observed in discs around solar and slightly subsolar-mass stars are not predicted in the BD regime, but ALMA will soon tell us whether these predictions are verified or not (talk by L. Testi).

Early evolution of very low-mass stars and brown dwarfs

Finally, during the last day of the workshop an overall picture of the early evolutionary stages of very low-mass stars and brown dwarfs was laid out in talks by I. Baraffe and L. Spezzi. As opposed to the assumption of steady mass accretion limited to the protostellar stage, as in previous pre-main sequence evolutionary models, new models now consider episodic and significant mass accretion rates also during the early phases of pre-main sequence evolution (talks by Baraffe and S. Offner). Episodic accretion acts on the internal structure of very low-mass stars and brown dwarfs, making them more compact (smaller radii) and hence appear less luminous, i.e. older, in the Hertzsprung–Russell diagram.

New average lifetimes for different evolutionary phases were constrained from Spitzer's Cores to Discs and Gould Belt surveys resulting in a revised Class 0 lifetime estimate of ~ 1/5 of the Class I lifetime (~ 0.44 Myr), while the classical T Tauri phase (Class II) represents the dominant phase during the pre-main sequence evolution of low-mass stars

(talk by L. Spezzi). As spectroscopic confirmation of a low effective temperature is often the final proof for a *candidate* substellar mass object, it is essential to build up spectral libraries for the lowest-mass objects. Some large sample spectroscopic projects, as well as detailed observations of individual objects, have been carried out, or are currently underway, as mentioned in talks by S. Antoniucci, J. Patience and J. Bochanski.

In summary, the workshop stimulated a very successful exchange of ideas and new results, and was very well received by the participants. The success of the workshop and its smooth and efficient practical organisation would have not been possible without the dedicated work of ESO students and fellows (Joana Ascenso, Giacomo Beccari, Eli Bressert and Sebastian Daemgen) and Christina Stoffer, who all provided excellent support before, during and after the meeting. The workshop gratefully acknowledges the receipt of financial support from ESO, the LMU/Excellence Cluster and from MPE. Most of the talks and posters are available from the workshop webpage[1].

Links

[1] Workshop webpage: http://www.eso.org/sci/meetings/2011/vlms2011.html

Brazilian Teachers and Students Visit Paranal and ALMA

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With Brazil poised to become the first non-European member of ESO, new opportunities exist to strengthen ties between the Brazilian astronomical community and ESO.

At the invitation of ESO’s Director General, a group of ten Brazilian teachers and students travelled to Chile in August 2011. All are members of the Louis Cruls Astronomy Club from the city of Campos in Rio de Janeiro state, and were led by Professor Marcelo Souza of Universidade Estadual do Norte Fluminense and with the support of Dr José Monserrat Filho, Advisor for International Cooperation from the Brazilian Space Agency.

Accompanied by the head of the Office for Science in Chile, the group visited the ALMA and Paranal sites during the week of 21–27 August. Seeing the ALMA array and the VLT up close was a dream come true for this enthusiastic group of amateur astronomers. Other highlights of the visit included an opportunity to chat with the ESO astronomer and fellow countryman, Claudio Melo, and to get an insider’s look at the VLT and ALMA operations.

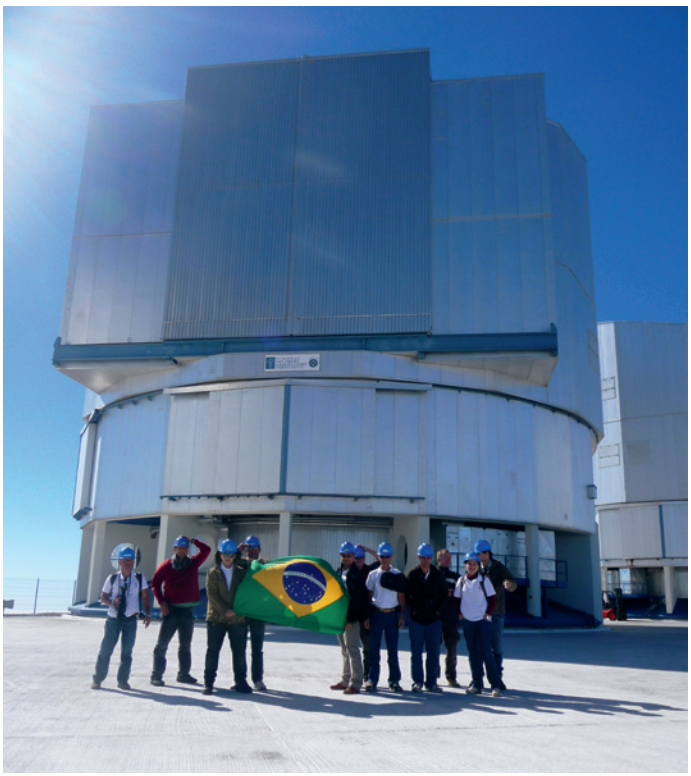

Figure 1. Teachers and students from the Brazilian Louis Cruls Astronomy Club during their visit to Paranal.

Brazil’s first astronaut, Marcos Pontes, has inspired millions of young Brazilians to consider scientific careers. “Brazil has a very bright future in science and technology,” he said, “but for this to come true, you have to have young people working in this area.” Thanks to the opportunity to visit the ESO and ALMA facilities in Chile, today’s student members of the Louis Cruls Astronomy Club may be inspired to become tomorrow’s professional astronomers and engineers in Brazil.