

IAU Symposium #344, **Dwarf Galaxies: From the Deep Universe to the Present**, the scientific highlights included discussions on current tensions between our observations of low-mass galaxies and our cosmological models, science presentations on ground-breaking research on low-mass galaxies, and a vision for the future.

Local Group Dwarf Galaxies:

In a discussion led by Andrew Cole, the symposium participants identified areas of Local Group dwarf galaxy research expected to see significant advancements. For example, what is the significance of the differences between Andromeda and Milky Way satellites? Specifically, proper motions will provide times of infall, pericenter passage, fly-by with other dwarfs, and general orbit reconstruction. GAIA is doing this for the Milky Way and JWST will be able to do this for the Andromeda system. Also looking forward with JWST, Fornax analogs will be revealed out to $z \sim 1$ with the HUDF and out to $z \sim 2.5$ with JWST. Helmut Jerjen (Australian National University, Australia) discussed possible origins for the ultra-faint stellar systems in the Milky Way halo.

Metallicity, Massive Stars, and Chemical Evolution:

The inclusion of the very successful cross-over session on metallicity, massive stars, and chemical evolution was suggested by Division H. The symposium brought together the massive stars and low-mass galaxy communities to discuss how stars form at extremely low metallicity and how that impacts the evolution of the galaxies.

Interstellar Medium and Star Formation:

Vianney Lebouteiller (Laboratoire AIM, France) showed how ultraluminous X-ray sources can become the dominant heating mechanism of the neutral gas in extremely low metallicity galaxies, with important implications on the regulation of star formation and on the relevance of usual diagnostics drawn from far-IR cooling lines such as [CII]. Through a multi-phase model of the metal-poor star-forming dwarf galaxy IZw18 together with a realistic ISM topology, he showed that the elusive molecular gas can exist only in tiny dense clumps and that [CII] and [OI] trace a purely atomic medium, contrary to somewhat more metal-rich galaxies where they are expected to trace the CO-dark H₂ gas. Yong Shi (Nanjing University, China) discussed dust-to-gas ratios in observations of molecular gas and dust in the most extremely low metallicity dwarf systems known.

Dwarf Galaxy - Environment Connection:

Invited speaker Claude Carignan (University of Cape Town, South Africa) discussed plans to use the SKA and FAST to search for missing dwarf galaxies and intergalactic HI clouds. Speaker Matthew Taylor (Gemini Observatory, USA) presented a newly discovered reservoir of dwarf galaxies in the Centaurus A group. Shami Chatterjee (Cornell University, USA) highlighted why dwarf galaxies are newly of interest to the variable star community: a dwarf galaxy is known to host a repeating fast radio burst.

Low Mass Galaxies at High Redshift:

A theme of the discussion in this session was, interestingly, what exactly is a dwarf galaxy at high redshift? Complete agreement was not reached but a majority supported a

definition based on stellar mass content. Invited speaker Xu Kong (USTC, China) gave an overview on how global galaxy properties of dwarfs change as a function of redshift. Invited speaker Hakim Atek (Institut d'astrophysique de Paris, France) discussed the role of dwarf galaxies from the peak of epoch of star formation to the epoch of reionization. Specifically, he showed how the prevalence of starbursting dwarfs increases with redshift as revealed by the UV luminosity function at $z \sim 6$ which appears to turn over when extended to the dwarf regime (Atek et al. 2018). This result is compatible with dwarfs reionizing the universe (given significant assumptions about the escape fraction, however).

Dwarfs as Cosmological Probes:

Invited speakers Alyson Brooks (Rutgers University, USA) and Julio Navarro (University of Victoria, Canada) discussed the cosmological formation of dwarf galaxies including how galaxies populate low mass haloes. Speaker Oliver Müller (Universität Basel, Switzerland) presented observations of a whirling plane of satellite galaxies around Centaurus A which are possibly at odds with the Lambda Cold Dark Matter paradigm because they show the phase-space correlation of the dwarf galaxies around Cen A, the third case such a system was discovered (Müller et al. (2018, Science, 359, 534). Speaker Isabel Santos-Santos (Universidad Autónoma de Madrid, Spain), however, showed using her simulations that she can reproduce such planes within Lambda CDM with coherent rotation due to their common positioning relative to the cosmic web and that persist over time.