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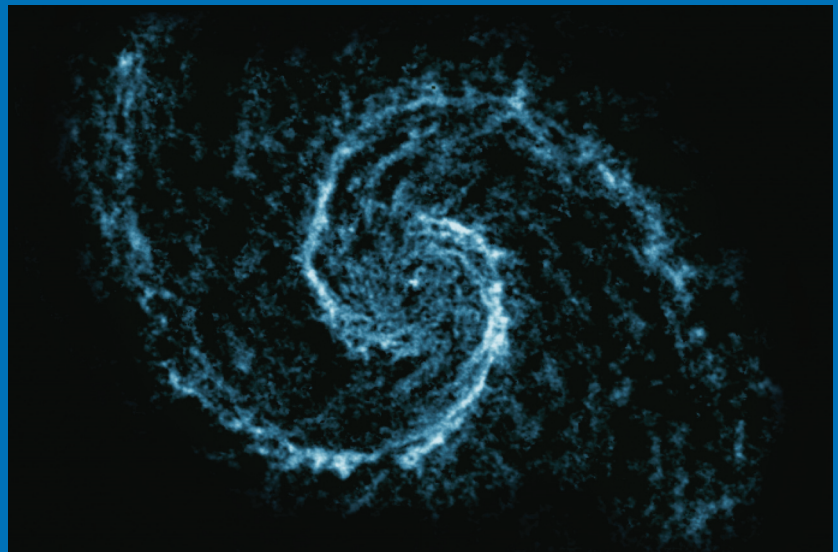
Tony Wong
Jürgen Ott

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MOLECULAR GAS, DUST, AND STAR FORMATION IN GALAXIES

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COVER ILLUSTRATION: THE WHIRLPOOL GALAXY IN CO

CO(1–0) line emission from the central 9 kpc of the Whirlpool Galaxy (M 51), as mapped by the PdBI Arcsecond Whirlpool Survey (PAWS; PI: E. Schinnerer). The CO emission, brightest in the spiral arms but still detectable in interarm regions, reveals the distribution of molecular gas on a scale of 40 pc, sufficient to resolve the largest molecular clouds. See article by Meidt *et al.* in Session 3.

Image credit: S. E. Meidt, D. Colombo, and PAWS team

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Edited by

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Preface

Understanding galaxy formation and evolution is at the heart of modern astronomy. Central to that goal is the necessity to improve our understanding of star formation, and thus the evolution of the interstellar medium (ISM) of galaxies. The relevant phenomena span vast spatial scales, requiring observations across the electromagnetic spectrum as well as state-of-the-art numerical simulations. To tackle these complex issues, IAU Symposium 292 (IAUS292), held from 20–24 August 2012 during the XXVIII General Assembly of the IAU in Beijing, China, focused on the detailed properties of the clouds where stars are born, the fuel and tracers of star formation, the quantification of star formation, and its effects on galaxy evolution. The symposium occurred two years after a conference with a similar theme (Molecules in Galaxies) organized by one of us (MB) at Oxford. The intervening two years saw a rapid growth in scientific output from facilities such as the Herschel Space Observatory and SOFIA airborne observatory, as well as the first results from the Atacama Large Millimeter/sub-millimeter Array (ALMA), making it timely to revisit these topics. More than 70 talks and 200 posters were presented over the course of 5 hot summer days in Beijing.

Of course, the first step towards understanding the ISM is to accurately constrain its physical and chemical properties. Over the past few years, Herschel and SOFIA have been generating revolutionary datasets on dust and excited/ionized species of the ISM closely connected to star formation (e.g., high- J CO lines and infrared diagnostic lines). Also discussed were early science results and the future potential of ALMA, which will revolutionize our understanding of molecular gas, the fuel for star formation. Complementary ground- and space-based programs in the X-ray, UV, optical, and radio were reviewed, in an effort to probe the relationships between star-formation tracers and the evolution of star formation over wide timescales. On small spatial scales (tens of parsecs), the incidence, distribution, internal properties (e.g. Larson relations), and formation/evolution of (giant) molecular clouds were an important topic of IAUS292. Such studies have until recently been limited to the Local Group, though recent results for M51 (see cover image) remind us how quickly capabilities are improving.

Beyond the Local Group, IAUS292 explored the molecular content of galaxies across both morphological types (dwarfs, spirals, early-types; active vs. non-active galaxies) and cosmological epochs (from the nearest galaxies to high-redshift quasars). Through observations of multiple species and transitions, the gas density, temperature, metallicity, radiation field, etc. can be determined for a diversity of sources and environments (e.g. photon-dominated regions; X-ray dominated regions; cosmic ray-dominated regions; active galactic nuclei). On spatial scales of kiloparsecs or less, the internal distribution and kinematics of the ISM of galaxies can be probed. Efforts there typically focus on comparative studies across galaxy types and environments. Crucially important is the link to star formation, which is being probed by empirical star formation relations (e.g. Kennicutt-Schmidt relation, FIR-radio correlation), by an improved understanding of the different ISM phases (e.g., neutral, molecular, and ionized), and by measurements of time lags since star formation as probed by various tracers.

New observations have been complemented with high-resolution simulations, which are now revisiting the long-standing questions of how turbulence in the ISM is generated, and to what extent turbulence inhibits star formation. The importance of accretion processes on both the molecular cloud scale and the galactic scale was stressed by several speakers.

Recent theoretical advances were expanded upon in Special Session 12, “Modern Views of the Interstellar Medium,” which followed IAUS292 during the second week of the General Assembly.

At even greater distances, IAUS292 explored the ISM and star-formation indicators of intermediate redshift galaxies, where the cosmic star formation rate peaks. These are presumably the progenitors of today’s galaxies (but which ones?). Similarly, for the highest redshift sources, observations probe the earliest phases of star formation when reionization is in full swing. Lastly, feedback mechanisms from both star formation and nuclear activity are increasingly believed to play a key role in understanding the star formation history of the universe within the hierarchical structure formation paradigm. As any feedback mechanism must have profound consequences for the ISM, and feedback is undoubtedly key to understanding the migration of galaxies from the blue cloud to the red sequence, IAUS292 also focused on the observational evidence and theoretical models of feedback, from molecular cloud to galaxy and cluster scales, and from local galaxies to the high-redshift universe.

Looking back on the conference, we can see tantalizing hints of things to come, including a resurgence in [C II] observations provided by Herschel, SOFIA, and ALMA, high-resolution mapping of high- J CO lines in galaxies, and new constraints on the still-puzzling submillimeter excess in dwarf galaxies. Of course, the real work at meetings occurs outside the auditorium, and many of us enjoyed the opportunity to learn more about astronomical developments in China and the East Asia region. We hope this book thereby provides an impetus for new contacts and collaborations.

Tony Wong, Martin Bureau, & Juergen Ott
January 4, 2013

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