Saas-Fee Advanced Course 38

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T. L. Wilson · Stéphane Guilloteau

Millimeter Astronomy

Saas-Fee Advanced Course 38

Swiss Society for Astrophysics and Astronomy
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Preface

The millimeter (mm) and sub-millimeter (sub-mm) wavebands are unique in astronomy in containing more than 1000 spectral lines of molecules as well as the thermal continuum spectrum of cold dust. They are the only bands in the electromagnetic spectrum in which we can detect cold dust and molecules far away in high-redshift galaxies, and nearby in low-temperature cocoons of protostars and protoplanets.

Observations in mm/sub-mm wavebands promise to make a decisive contribution to the following key questions in the current astronomy:

- The origins of galaxies: Current optical studies are limited to the very brightest objects. In mm and sub-mm wavebands, it is possible to detect galaxies 100 times fainter and dust-obscured out to the epoch of reionization. The redshifts of these galaxies can be measured directly and precisely, either photometrically, based on the shape of the spectral energy distribution, or spectroscopically, using the many available spectral lines. A complete picture of the star formation history of the universe requires the knowledge of discrete sources that produce the far-infrared/sub-mm background.
- The evolution of galaxies: Images of the molecular gas in galaxies at the resolution of the Hubble Space Telescope (HST) will give the information on both the parsec and kiloparsec scales needed to explore the relationship between star formation, gas density, and gas kinematics, in comparison with other tracers, like the atomic gas, Hα, or radio continuum. The role of density waves and spiral structure, the mechanisms of starbursts and the associated feedback processes (such as outflows of molecular gas, bubbles, and winds), and the effects of mergers can hence be addressed.
- Star and planet formation: The mm/sub-mm wavebands are ideal for studying how gas and dust evolve from a collapsing molecular cloud core into a circumstellar disk that can form planets by providing unique information on the kinematics and mass distribution inside the cores and their envelopes. When the newly formed stars are surrounded by protoplanetary disks, imaging the gas and

dust on scales of several astronomical units is the only way to study the earliest stages of planet formation.

Given these important prospects and with the largest mm/sub-mm facility, the Atacama Large Millimeter/Sub-millimeter Array (ALMA), having started its operation, the members of the Swiss Society for Astrophysics and Astronomy chose this topic for the 38th Saas-Fee advanced course. ALMA is undoubtedly producing a major step in astrophysics comparable to that provided by the HST and will work in synergy with the James Webb Space Telescope.

The course took place in the small Swiss village of Les Diablerets, Switzerland. The selected lecturers, T. L. Wilson, Stéphane Guilloteau, and Pierre Cox, have offered to about 60 participants outstanding and pedagogical lectures on the millimeter observational techniques and the above scientific topics. We wish to sincerely thank them for their successful and high scientific level course. We express special thanks to T. L. Wilson and Stéphane Guilloteau whose determination and hard work in writing their respective chapters enabled to assemble this book.

Finally, we warmly thank the course secretary, Myriam Burgener Frick, for all her help, enthusiasm, and devotion in the practical organization.

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Contents