Foreword
Multi-line Diagnostics of the Interstellar Medium

The IRAM conference "Multi-line Diagnostics of the Interstellar Medium" took place at the Côte d'Azur in Nice (France), April 4-6, 2022. The conference has brought together more than 150 scientists scientists from a wide interdisciplinary community to address recent advances, current challenges and future directions in millimeter and submillimeter astronomy. The program included 60 talks combined with dedicated sessions to discuss 50 posters covering a wide range of contemporary topics in mm-astrophysics and beyond. In the evening of the 2nd day, the participants met at the Negresco hotel at the Promenade des Anglais for a relaxed conference dinner with after-dinner speaker and Nobel prize winner Reinhard Genzel. After a long pause due to the pandemic, the participants really enjoyed meeting and exchanging again face-to-face in-person with their colleagues.

The conference program covered many aspects of millimeter and submillimeter astronomy, from the chemical complexity of the interstellar medium in the local and early Universe, to that of the environment of stars in the earliest stages of formation and the physical and chemical evolution of galaxies over cosmic time. Topics included in addition data analysis, theoretical modeling and simulations, and laboratory spectroscopy.

The meeting provided also a lively platform for discussing new approaches exploiting the unique capabilities of the world's best millimeter and submillimeter facilities. With a special focus on the expanded capabilities of the NOEMA interferometer with its 12 antennae and the unique capabilities of the IRAM 30-meter telescope, participants discussed the possibilities of spectral line measurements of molecular and atomic species with higher sensitivity, larger fields-of-view, better spectral and spatial resolutions than is currently possible.

Recent advances in broad band millimeter and submillimeter instrumentation, as well as modelling and laboratory measurements have changed the nature of research on interstellar matter. With modern observatories one can now measure a vastly increased number of lines from a great number of molecular and atomic species simultaneously. Spectroscopic data will also be available over larger areas by means of multi-beam instruments or interferometric mosaicking and on-the-fly imaging techniques. Current and upcoming modeling and analysis methods including statistical treatments of large data sets and source surveys will also open new opportunities.

These facts will form the basis for the next crucial steps towards a global description of cold and warm interstellar matter responsible for star and planet formation on local and cosmological scales. Modern multi-line observations have the power to grasp molecular complexity to its full extent and its dependence on local conditions, to determine physicochemical processes within and potentially also to reconstruct the history of the interstellar medium (ISM). This increased understanding will provide a quantitative foundation for sources where fewer detectable lines are available, such as in high-redshift galaxies. Comparisons to dust emission and multi-wavelength studies will pin down key parameters such as metallicity, temperature, density, and radiation fields. All these advances will lead to the possibility to understand structure formation from cosmological scales down to the circumstellar environment in greatly

enhanced detail.

Laure Bouscasse, Carsten Kramer, Frédéric Gueth
Scientific editors of the conference on "Multi-line Diagnostics of the Interstellar Medium".