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Editorial: The Sun seen with the Atacama Large mm and sub-mm array (ALMA)—First results[1]

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Editorial on the Research Topic
The Sun Seen with the Atacama Large mm and sub-mm Array (ALMA)—first results

The Atacama Large Millimeter and submillimeter Array (ALMA; Wootten and Thompson, 2009) is a unique general-purpose radio interferometer for exploring the Universe at millimeter (mm) and sub-millimeter (sub-mm) wavelengths.

Observing the Sun with ALMA is not straightforward, due to the high intensity of its emission, its motion (both the apparent motion across the sky and the differential rotation), its size which is larger than the field of view of a single ALMA antenna, and its highly variable emission as a result of a multitude of phenomena, ranging from oscillations to flares. After a significant testing and commissioning effort, ALMA developed solar observing capability, with the first usable data coming out of the commissioning period in December 2015 (see **Figure 1** for an example). The possibility of user proposals opened with Cycle 4 (October 2016—September 2017 and the first scientific solar observations were carried out in December 2016.

When the call for this Research Topic was launched, more than 50 refereed articles using ALMA solar observations had been published. It was thus time to put together these first results in a Research Topic that would serve both as a report of hitherto accomplishments and as a guide for the future. The response was enthusiastic, with practically all research groups implicated in solar ALMA observing responding positively. We would like to express our sincere thanks to all colleagues, authors and reviewers, that worked hard to make this Research Topic possible and we hope that it will become a reference for future work.

This Research Topic includes 12 contributions with more than 50 authors. We start with an overview of solar observing with ALMA, by Bastian et al., in which the authors describe the challenges of using the instrument for solar observing, its capabilities and limitations, as well as the prospects for the future, as ALMA is evolving and improving rapidly. The review of quiet

1 Dedicated to the memory of our good friend and colleague Rob Rutten (1942-2022).

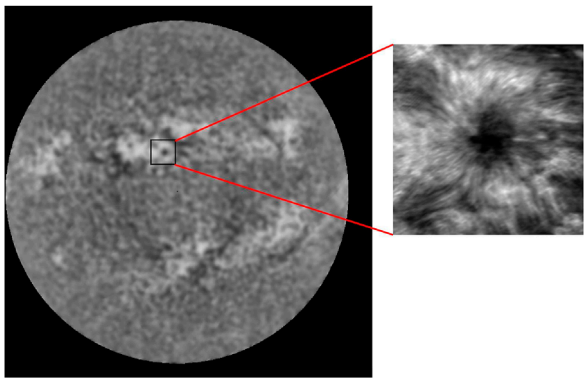

FIGURE 1
ALMA images of the Sun at 1.3 mm (band 6). Left: Full disk image obtained by scanning with a single dish; the spatial resolution is $30''$. Right: High resolution ($1''$) image of the region around the sunspot, obtained in interferometric mode with mosaicking. Both images were obtained on 18 December 2015, during the commissioning period and were processed by the authors for better visibility of the disk features.

Sun ALMA observations by Alissandrakis et al. comes next, where the results on the temperature structure of the chromosphere, the chromospheric network and spicules are presented, followed by the research article by Tarr et al., which compares the 3 mm brightness temperature with the Hα line width in the weak solar network.

Small-scale dynamic phenomena and oscillations are an important issue for solar physics, and the relevant ALMA results are reviewed by Nindos et al. Recent advances in numerical computations have produced sophisticated magnetohyrodynamic models of the solar chromosphere and their possible signatures at mm-wavelengths are discussed in the review by Wedemeyer et al. that follows.

Prominences and filaments are a basic ingredient of the solar chromosphere, and their properties derived from ALMA observations are discussed in the review by Heinzel et al. In a related research article that follows, da Silva Santos et al. present the results of their study of an active region filament observed by ALMA and IRIS.

Active regions are places with concentrated magnetic flux, which play a crucial role in energetic solar phenomena. Their properties, as revealed with ALMA, are reviewed by Loukicheva and Reardon. In two related research articles, Abe et al. analyze their observations of time variations of the chromospheric temperature in a plage, while de Oliveira e Silva et al. discuss the modeling of active regions with 3-dimensional magnetic field extrapolations.

Although no ALMA observations of solar flares have been published yet, Fleishman et al. share their thoughts on what we can learn from mm/submm observations in a mini review. The Research Topic concludes with an article on the radio emission from supra-arcade downflows by Zurbriggen et al.

As this Research Topic was near completion, our good friend and colleague Robert Rutten passed away. Rob was involved in the early stages of this Research Topic. He was a distinguished researcher and educator, pioneer in many aspects of Solar Physics, including the appearance of Hα features in ALMA images (Rutten, 2017), with brilliant ideas and acute but constructive criticism. He will be remembered by the entire solar physics community, and we dedicate this Research Topic to his memory.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of interest

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