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Artificial observations of the Sun – The scientific potential of optimizing future solar observatories

The *Atacama Large Millimeter/submillimeter Array* (ALMA) offers new diagnostic capabilities that complement other commonly used diagnostics for exploring our Sun. In particular, ALMA's abilities as an essentially linear thermometer of the chromospheric gas at unprecedented spatial resolution at mm wavelengths and future polarization measurements have great scientific potential. In concert with current and future ground-based and space-borne observatories, ALMA will thus certainly significantly contribute to answering long-standing questions about the structure, dynamics and energy balance of the outer layers of the solar atmosphere. In this context, ALMA data are also important for constraining and further developing numerical models of the solar atmosphere, which in turn are often crucial for the interpretation of observations. Given the highly intermittent and dynamic nature of the solar chromosphere, realistic forward modeling requires time-dependent three-dimensional radiative magnetohydrodynamics that account for non-equilibrium effects and, typically as a separate step, detailed radiative transport calculations leading to synthetic observables that can be compared to observations. Additionally accounting for instrumental and seeing effects further aids the interpretation of observations and allows for designing and optimizing observing and post-processing strategies. The resulting scientific gain is demonstrated here using the example of the Solar ALMA Simulator (SASim). Applications of this approach to potential mm and radio observations with future facilities such as FASR and AtLAST are highlighted and the transfer of possible findings to the optimization of observations at shorter wavelengths (e.g., with MUSE or IRIS) are outlined.

Primary author: WEDEMEYER, Sven (Rosseland Centre for Solar Physics, University of Oslo)

Presenter: WEDEMEYER, Sven (Rosseland Centre for Solar Physics, University of Oslo)

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