First ALMA Observation of a Solar Plasmoid Ejection from an X-ray Bright Point

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Eruptive phenomena such as plasmoid ejections or jets are important features of solar activity and have the potential to improve our understanding of the dynamics of the solar atmosphere. Such ejections are often thought to be signatures of the outflows expected in regions of fast magnetic reconnection. The 304 Å EUV line of helium, formed at around 10^5 K, is found to be a reliable tracer of such phenomena, but the determination of physical parameters from such observations is not straightforward. We have observed a plasmoid ejection from an X-ray bright point simultaneously at millimeter wavelengths with ALMA, at EUV wavelengths with SDO/AIA, and in soft X-rays with Hinode/XRT. This paper reports the physical parameters of the plasmoid obtained by combining the radio, EUV, and X-ray data. We consider three basic working hypotheses to consider. (1) The plasmoid consists of (roughly) isothermal plasma that is optically thick at 100 GHz. (2) The plasmoid consists of isothermal plasma that is optically thin at 100 GHz. (3) The plasmoid consists of multi-thermal plasma. As a result, we conclude that the plasmoid can consist either of (approximately) isothermal ~10^5 K plasma that is optically thin at 100 GHz, or a ~10^4 K core with a hot envelope.

This analysis demonstrates the value of the additional temperature and density constraints that ALMA can provide. In addition, at higher frequencies the spatial resolution of ALMA is close to that achieved with space-borne telescopes such as AIA, providing the ability to spatially resolve the same features at very different wavelengths, and providing complementary physical information.

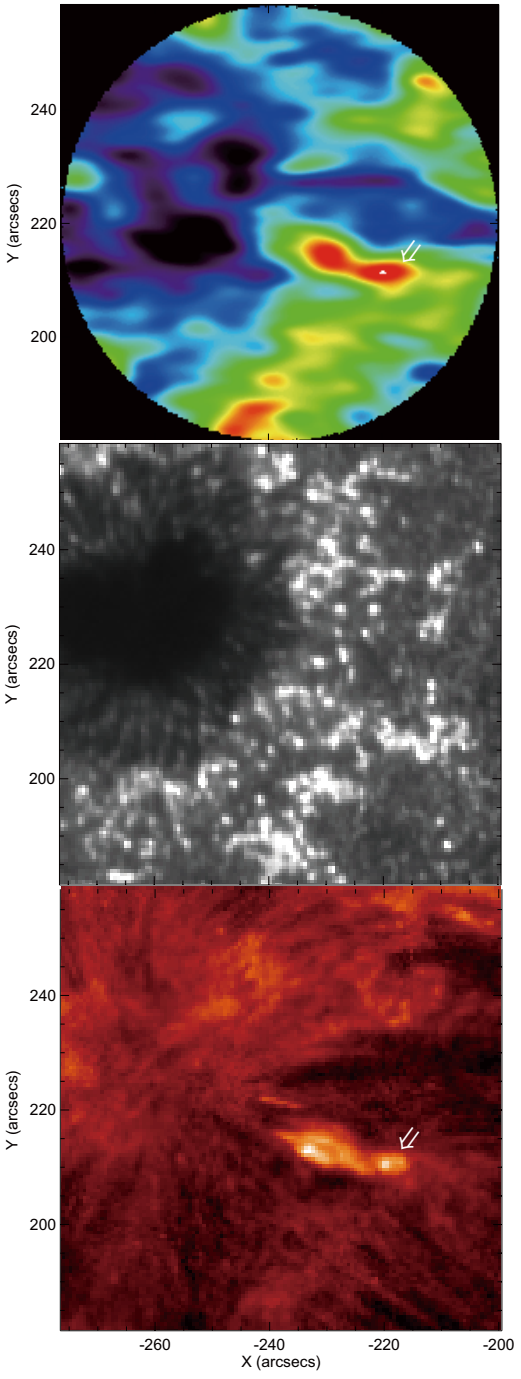

Figure 1: The leading sunspot of active region NOAA12470 observed with ALMA at Band 3 (100 GHz, upper panel), in ultraviolet continuum from the lower chromosphere (AIA1700, middle panel), and the He II transition-region line (AIA304, lower panel). The white arrows indicate an erupted plasmoid.

Reference

[1] Shimojo, M., et al.: 2017, *ApJ*, **841**, L5.