

ALMA Discovery of Solar Umbral Brightening at $\lambda = 3$ mm

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We report the discovery of solar umbral brightening at a wavelength of 3 mm using the Atacama Large Millimeter/sub-millimeter Array (ALMA). Sunspots are the most prominent features on the solar surface, but many of their aspects are surprisingly poorly understood. We analyzed a $\lambda = 3$ mm (100 GHz) mosaic image obtained by ALMA, which includes a large sunspot within the active region AR12470 on December 16, 2015. The 3 mm map has a field-of-view and spatial resolution, which is the highest spatially-resolved map including an entire sunspot at this frequency range. We find a gradient of 3 mm brightness from a high value in the outer penumbra to a low value in the inner penumbra/outer umbra. Within the inner umbra, there is a marked increase in 3mm brightness temperature, which we call umbral brightening. This enhanced emission corresponds to a temperature excess of 800 K relative to the surrounding inner penumbral region and coincides with excess brightening in the 1330 and 1400 Å slitjaw images of the Interface Region Imaging Spectrograph (IRIS), adjacent to a partial lightbridge. This $\lambda = 3$ mm brightening may be an intrinsic feature of the sunspot umbra at chromospheric heights, or it could be related to a coronal plume since the brightening was coincident with the footpoint of a coronal loop observed at 171 Å. The $\lambda = 3$ mm brightening is near a region of variable brightening observed at 1330 Å in part of the penumbra of the sunspot.

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