Exploring EUV Spicules Using 304 Angstrom He II Data from SDO/AIA

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Abstract

We present results from a statistical study of He II 304 Å EUV spicules at the limb of the Sun. We also measured properties of one macrospicule; macrospicules are longer than most spicules, and much broader in width than spicules. We use high cadence (12 sec) and high-resolution (0.6 arcsec pixels) resolution data from the Atmospheric Imaging Array (AIA) instrument on the Solar Dynamic Observatory (SDO). All of the observed events occurred near the solar north pole, where quiet Sun or coronal hole environments ensued. We examined the maximum length, maximum rise velocities, and lifetimes of 33 EUV spicules and the macrospicule. For the bulk of the EUV spicules these quantities are, respectively, \(-10,000 \pm 10,000 \text{ km} \times 200 \pm 100 \text{ km/s} \) and \(-100 \pm 50 \text{ sec} \times 50 \pm 25 \text{ km/s} \) for the macrospicule. We were not able to identify \(-10 \text{ spicules} \) that satisfied these criteria. From movie \(3 \) we identified \(-4 \text{ spicules} \), because much of the time a large, wide macrospicule dominates that movie, obscuring the smaller spicules along the same line-of-sight.

Procedure

We examined the AIA 304 Å movies over the regions and times of Table 1. For each selected spicule, we measured the projected length from the photospheric limb, with the white-light limb being calculated from the Sun-Earth distance at the times of the observations. Typically the line in the 304 Å images is \(-15 \pm 15 \text{ km/s} \) above the photospheric limb, and the minimum-observable length (height) for the 304 Å spicules is \(-7000 \text{ km} \). We measured the top of the spicules visually, after verifying that the apparent top location of the features was not significantly influenced by the intensity scaling of the displayed images. We derived velocities from the derivative of the length-time trajectories (after applying a running box-car smoothing to the trajectories), and fit first- and second-order polynomials to the trajectories. From the second-order fits we could obtain an acceleration term, which we could compare with the solar gravitational acceleration.

Results

We found the 304 Å spicules to have lengths \(-50,000 \pm 20,000 \text{ km} \), maximum rise velocities \(-20 \pm 10 \text{ km/s} \), and lifetimes \(-150 \pm 50 \text{ sec} \). Velocities averaged over the rise of the spicules were \(-15 \pm 10 \text{ km/s} \). These lengths and lifetimes are gravity in agreement with earlier EUV and UV observations (e.g., Cook et al., 1985; Durech et al., 1988). Our lengths are much longer than those of the majority of chromospheric spicules, and as such they may represent the larger extensions of chromospheric spicules. A good possibility that they are the more-extended material of chromospheric spicules after it has become heated and has faded from view at the footpoints where the chromosphere is observable (e.g., Feayre and Kopp 1976, Sterling 1998, De Pontieu et al., 2007).

We found many of the 304 Å spicules to fit quadratic trajectories, with effective gravity often significantly smaller than that of solar gravitation. This is consistent with the possibility that they form and further develop due to a prolonged deposition of energy at their base, or due to a rapid heating of chromospheric material that expands to form the spicule. The pressure increase at the base resulting from such an energy input would oppose and thereby weaken the influence of gravity. This study only included one macrospicule, which was longer \(-50,000 \text{ km} \), faster (max velocity \(-130 \text{ km/s} \), and longer \(1800 \text{ sec} \) than the bulk of the 304 Å spicules. Our measured values are comparable to some of the macrospicules measured by Moschou et al. (2012). Further studies are required to determine the nature of \(\sim 1 \text{ Å} \) features and the approximate role of the same driving mechanisms.

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Summary and Discussion

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