Using 2012 Venus transit for solar metrology

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Edmond Halley advocated converting Venus transit timings into a distance to the Sun. Venus is closer to Earth than Mercury and has a bigger diameter. Therefore, Venus transits provide a distance with a better accuracy than the Mercury ones. These transits occur in pair eight years apart, and are separated by time intervals of 121.5 years and 105.5 years. For Halley, the last pair of Venus transits occurred in 1631/1639, as predicted by Johannes Kepler, and the next ones would occur in 1761/1769 and again in 1874/1882. The parallax of planet Mars and, later, a method involving determining the constant of aberration, also provided a value for the astronomical unit. Since the beginning of the 18th century, independent determination of the astronomical unit allowed planetary transits to be used to measure the solar radius. Similarly the solar diameter has been determined from precise measurements of total solar eclipses. From space, measurements of planetary transits are not affected by optical distortions caused by the Earth's atmosphere, they have significant advantages over ground observations. This work details the solar radius determined during the Venus transit of June 2012 by the by Helioseismic and Magnetic Imager (HMI) and the Atmospheric Imaging Assembly (AIA) instruments on the Solar Dynamics Observatory (SDO) spacecraft. Two different methods were utilized to determine the solar radius using images of Sun taken by the HMI instrument. The first technique fit the measured trajectory of Venus across the Sun for seven wavelengths across the Fe I absorption line at 6173 Å. The solar radius determined from this method varies with the measurement wavelength, likely reflecting the variation in the height of line formation. The figures 1 and 2 show respectively images of Venus ingress and egress for the 2012 transit as well as the Venus center and the solar limb fit. We found the geometric x and y contact positions with the solar limb for each instrumental configuration set. The second method measured the area of the Sun obscured by Venus to determine the transit duration from which the solar radius was derived. This analysis focused on measurements taken in the continuum wing of the line, and applied a correction for the instrumental PSF of the HMI images. Measurements taken in the continuum wing of the 6173 Å line, resulted in a derived solar radius at 1 AU of 959".5 ± 0".02 (695,946 ± 15 km). The two radius determinations from the two methods are consistent to within the 0".07 estimate of the PSF correction to the HMI images. The AIA instrument observed the Venus transit at ultraviolet wavelengths. Using the solar disk obscuration technique similar to that applied to the HMI images, analysis of the AIA data resulted in values of R_{sun} = 963".04' at 1600 Å and R_{sun} = 961".76 at 1700Å .

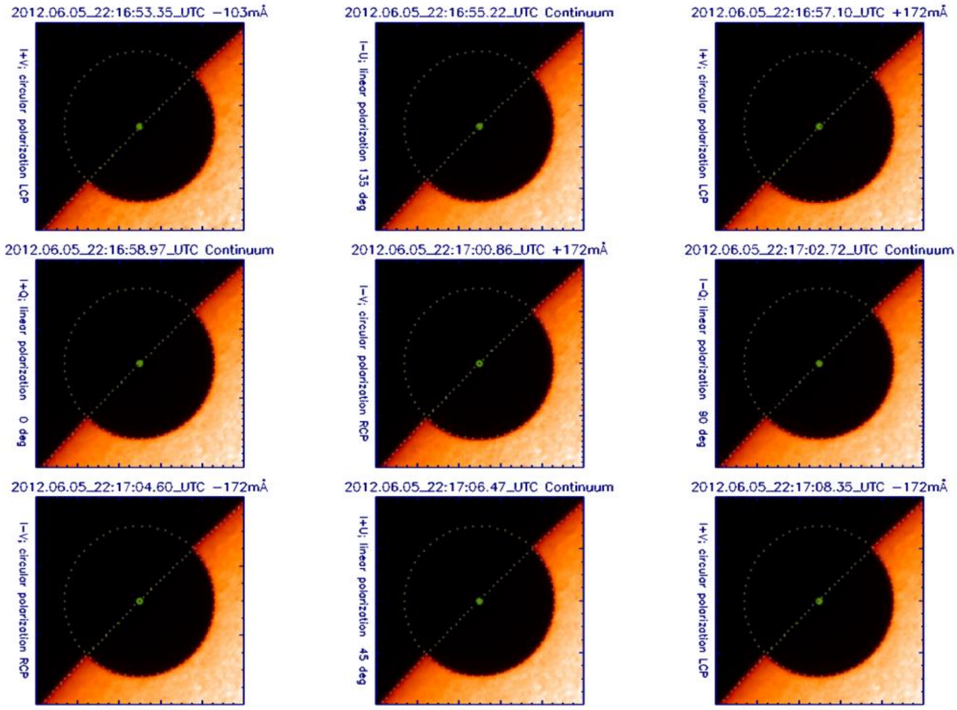

Figure 1. 2012 Venus Center Ingress as seen from HMI-SDO.

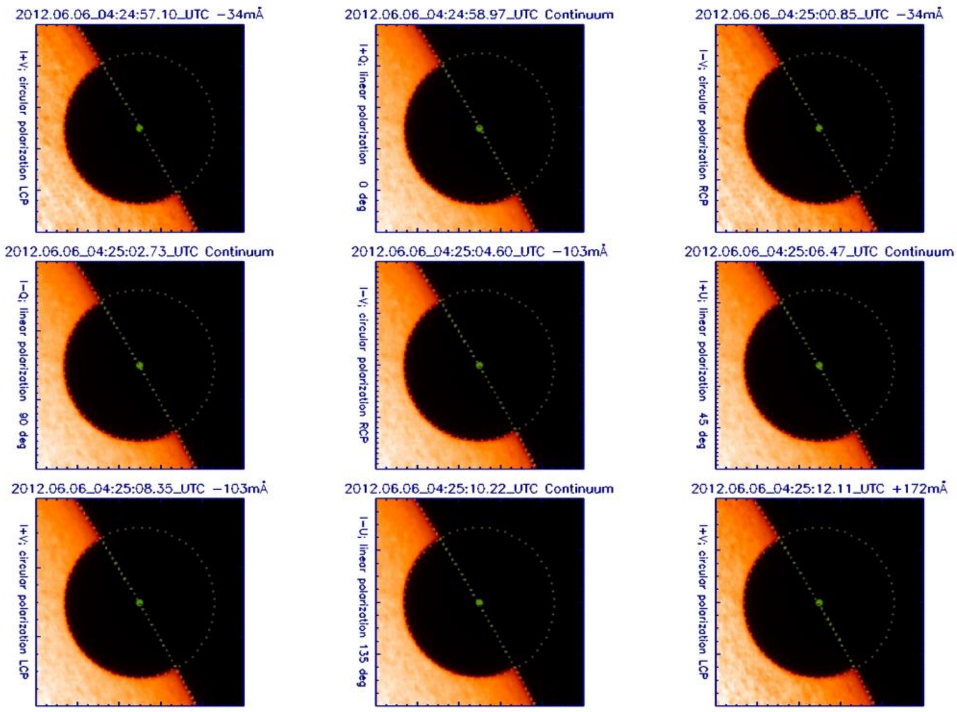

Figure 2. 2012 Venus Center Egress as seen from HMI-SDO.