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Catalog of Large-Amplitude Oscillations in Solar Prominences

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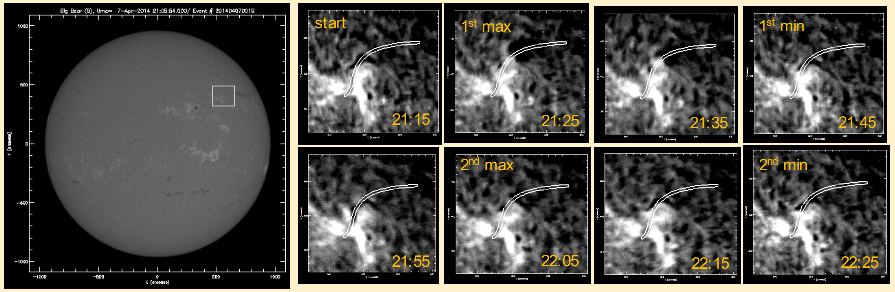
The solar dynamo generates magnetic fields storing energy in 3D magnetic configurations where prominence mass can form. Prominences are therefore related to reservoirs of free magnetic energy in the solar atmosphere that is often released abruptly, producing eruptive phenomena (flares, CMEs). Large-amplitude oscillations (LAOs) in prominences involve motions with velocities above 20 km/s and large portions of the filament that move in phase and are easily observed by ground- and space-based instruments. The LAO properties (e.g. period, damping time) are directly related to the morphology of prominences and the process of formation. Understanding the prominence evolution is therefore key to our understanding of the evolution of magnetic fields on the Sun and their relationship to eruptive phenomena.

A catalog of Large-Amplitude Oscillations (LAOs) in solar prominences is compiled in the scope of the International Space Science Institute (ISSI) International team “Large-Amplitude Oscillations in Solar Prominences”, led by Manuel Luna. The catalog is based on the H-alpha observations performed by the Global Oscillation Network Group (GONG) in 2011 and 2014 to cover lower and higher solar-activity periods, respectively. We list and classify all well-defined LAOs in these two time periods. In an ongoing research we are parametrizing the oscillations and identifying the triggering agents/events. The catalog is foreseen to be a starting point for case studies, and in addition, will serve for a comprehensive statistical study of LAO properties to advance our understanding of the nature and excitation mechanisms of LAOs, and the nature of prominences in general.

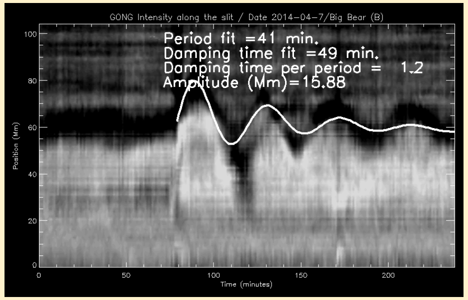
BUILDING THE LAO CATALOG

Step 1: detecting a LAO



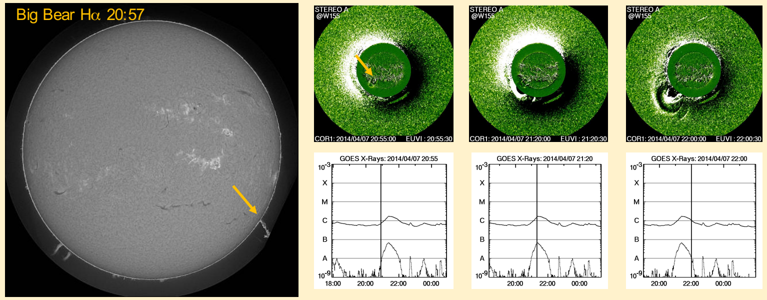
The GONG network telescopes are placed around the world at Learmonth (Australia), Udaipur (India), El Teide (Spain), Cerro Tololo (Chile), Big Bear (California, USA) and Mauna Loa (Hawaii, USA). The GONG Hα images allow to identify filaments easily and to follow LAO motions, which are detected by eye by visualizing the data (using Solar data viewer available at gong2.nso.edu). LAOs are seen as periodic motions of parts of filaments (or whole filaments), where we only select events where the periodic motion is clear and discard apparent counter streaming flows or oscillations which are not clear. We focus on two time periods: (1) near solar minimum – since August 2010 (when the network started to operate) to July 2011, and (2) near solar maximum – since January 2014 to December 2014.
It should be noted that visual identification of LAOs is only step 1 in building the catalog, i.e. not all visually detected LAOs are suitable for further analysis (step 2) because amplitudes are too small or the motion is too complex to track it with a slit. After the step 2 (time-distance diagrams) the oscillation is either confirmed as an actual LAO or discarded.

Step 2: Time-distance diagrams



To analyze the oscillatory movement and derive its parameters time-distance diagrams are produced using slits along the path of motion. The slits from consecutive images are then folded next to each other in a manner that the x-axis corresponds to the timeline, whereas the y-axis corresponds to the spatial extent in the direction of the movement and the intensity profile outlines the oscillatory movement (see e.g. Luna et al., 2014, ApJ).
In order to encompass the entire motion in the filament it is necessary to follow the motion of the large-amplitude displacements with curved paths. For that purpose we use a procedure involving curved slits. First the path of motion is selected by clicking on the image to produce points which are fitted with a curve. The curve is then divided into segments which are used instead of pixels when folding slits next to each other, where a procedure has been developed to account for the fact that the coordinates are not continuous (Luna et al., in preparation).
The parameters of the oscillatory motion (amplitude, period and damping time) are derived from time-distance diagrams by fitting a damped harmonic function (exponentially decreasing sinusoid).

Step 3: Identifying triggering agents



We analyze whether or not LAO was triggered by an eruptive event and to each LAO we try to associate a flare, CME or EUV wave. For that purpose we first determine visually whether a flare or eruptive prominence is observed in the corresponding GONG Hα image prior to the start of the oscillation. The timespan in which we would expect to observe the trigger is limited by the distance of the triggering flare/CME/EUV wave source region to the filament and expected speed range of the disturbance (400-1200 km/s), which is estimated based on the ”realistic” expected values for Alfven speed. We use the online SOHO LASCO CME catalog (available at cdaw.gsfc.nasa.gov), which provides CME observations in LASCO coronagraph, as well as flare observations in EUV imager and GOES X-ray flux. CME is associated to a flare/eruptive filament using temporal and spatial criteria (see Vršnak et al., 2005, A&A). For backsided events we use STEREO observations (in 2014 when its field of view captures the back side of the Sun, STEREO COR CME catalog available at cdaw.gsfc.nasa.gov). In addition, we search an online large-scale coronal propagating fronts (LCPFs) catalog by N. Nitta (available at aia.lmsal.com) for possible associated EUV wave.
It should be noted that not all LAOs can be associated with a possible flare/CME/EUV wave trigger. However, when possible, this allows speed estimation of the disturbance that triggered LAO.