**1996 to 2015**

Seong-Gyeong Jeon, Yong-Jae Moon, Kangwoo Yi, and, Harim Lee
*School of Space Research, Kyung Hee University, Korea,*

In this study we have made a statistical investigation on the kinematic classification of coronal mass ejections (CMEs) using about 4,000 SOHO/LASCO CMEs from 1996 to 2015. For this we use their SOHO/LASCO C3 data and exclude all poor events. Using the constant acceleration model, we classify these CMEs into three groups: Acceleration group, Constant Velocity group, and Deceleration group. For classification we adopt four different methods: Acceleration method, Velocity Variation method, Height Contribution method, and Visual Inspection method. Our major results are as follows. First, the fractions of three groups depend on the method used. Second, the results of the Height Contribution method are most consistent with those of the Visual Inspection method, which is thought to be most promising. Third, the fractions of different kinematic groups for the Height contribution method are: Acceleration (35%), Constant speed (47%), and Deceleration (18%). Fourth, the fraction strongly depend on CME speed; the fraction of Acceleration decreases from 0.6 to 0.05 with CME speed; the fraction of Constant increases from 0.3 to 0.7; the fraction of Deceleration increases from 0.1 to 0.3. Finally we present dozens of CMEs with non-constant accelerations. It is found that about 40 % of these CMEs show quasi-periodic oscillations.

### [구 SS-09] Estimation of CME 3-D parameters using a full ice-cream cone model

Hyeonock Na and Yong-Jae Moon
*School of Space Research, Kyung Hee University*

In space weather forecast, it is important to determine three-dimensional properties of CMEs. Using 29 limb CMEs, we examine which cone type is close to a CME three-dimensional structure. We find that most CMEs have near full ice-cream cone structure which is a symmetrical circular cone combined with a hemisphere. We develop a full ice-cream cone model based on a new methodology that the full ice-cream cone consists of many flat cones with different heights and angular widths. By applying this model to 12 SOHO/LASCO halo CMEs, we find that 3D parameters from our method are similar to those from other stereoscopic methods (i.e., a triangulation method and a Graduated Cylindrical Shell model). In addition, we derive CME mean density ($\bar{\rho}_{CME} = \frac{M_{total}}{V_{cone}}$) based on the full ice-cream cone structure. For several limb events, we determine CME mass by applying the Solarsoft procedure (e.g., cme_mass.pro) to SOHO/LASCO C3 images. CME volumes are estimated from the full ice-cream cone structure. For the first time, we derive average CME densities as a function of CME height for several CMEs, which are well fitted to power-law functions. We will compare densities (front and average) of geoeffective CMEs and their corresponding ICME ones.

### [구 SS-10] Radial and azimuthal oscillations of 24 Halo Coronal Mass Ejections using multi spacecraft

Harim Lee[1], Yong-Jae Moon[1], V. M. Nakariakov[1,2]
[1]*School of Space Research, Kyung Hee University, Yongin, Korea,*
[2]*Centre for Fusion, Space & Astrophysics, Physics Department, Univ. of Warwick, UK*

We have made an investigation on the radial and azimuthal wave modes of full halo coronal mass ejections (HCMEs). For this, we consider 24 HCMEs which are simultaneously observed by SOHO and STEREO A & B from August 2010 to August 2012 when they were roughly in quadrature. Using the SOHO/LASCO C3 and STEREO COR2 A & B running difference images, we estimate the instantaneous apparent speeds of the HCMEs at 24 different position angles. Major results from this study are as follows. First, there are quasi-periodic variations of the instantaneous radial velocity with the periods ranging from 24 to 48 mins. Second, the amplitudes of instant speed variations are about a third of the projected speeds. Third, the amplitudes are found to have a weak anti-correlation with period. Our preliminary identification from SOHO observations shows that there are several distinct radial and azimuthal wave modes: m=0 (radial) for five events, m=1 for eleven events, m=2 for three events, and unclear for the other events. In addition, we are making a statistical investigation on the oscillation of 733 CMEs to understand their physical origins.

### [구 SS-11] Competition between ICME and crustal magnetic field on the loss of Mars