

## Kinematic properties of slow ICMEs and modification of an equation for a drag model

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We report kinematic properties of slow interplanetary coronal mass ejections (ICMEs) detected by interplanetary scintillation (IPS) observations, and propose a modified equation for the ICME motion. Understanding of ICME propagation is very important for space weather forecasting. We believe that the radial motion of ICME is governed by a drag force due to interaction with the background solar wind and the magnitude of the force is proportional to the difference between speeds. Earlier studies dealt mainly with propagation of ICMEs moving faster than the solar wind, while observational studies for propagation of slow ICMEs were rare. The IPS observations have been carried out since the early 1980s using the 327MHz radio-telescope system of the Solar-Terrestrial Environment Laboratory, Nagoya University. These observations allow us to probe into the inner heliosphere with a cadence of 24 hours. We take advantage of the IPS observations to determine speeds and accelerations of slow ICMEs. In this study, we identified 59 ICMEs from the IPS observations during 1997-2011. Here, we define that  $V_{SOHO}$ ,  $V_{IPS}$  and  $V_{bg}$  are the initial speed of ICME, speed of that in the interplanetary space, and speed of background solar wind, respectively. Using the values of these, we classify the 59 ICMEs into three types of ICMEs, *i.e.*, fast ( $V_{SOHO} - V_{bg} > 500 \text{ km s}^{-1}$ ), moderate ( $0 \text{ km s}^{-1} < V_{SOHO} - V_{bg} < 500 \text{ km s}^{-1}$ ), and slow ( $V_{SOHO} - V_{bg} < 0 \text{ km s}^{-1}$ ). Here, we eliminate ICMEs exhibiting unusual values of  $V_{IPS} - V_{bg} > 500 \text{ km s}^{-1}$  for the moderate and of  $V_{IPS} - V_{bg} > 100 \text{ km s}^{-1}$  for the slow as events having a strange acceleration, and analyze the remaining 19 fasts, 28 moderates, and 5 slows. Our analyses for slow ICMEs show that  $a_{ave} = -k_1(V - V_{bg})$  is more suited than  $a_{ave} = -k_2(V - V_{bg})|V - V_{bg}|$  to describes their motion, where  $a_{ave}$  is the average acceleration,  $k_1$  and  $k_2$  are coefficients, and  $V$  is propagation speed of ICME. This result is the same as that for ICMEs having  $V_{SOHO} - V_{bg} > 0 \text{ km s}^{-1}$  (*i.e.* a group of the fasts and moderates). In addition, we also found from examinations of all ICMEs above that the value of the coefficient  $k_1$  has velocity dependence. On the basis of these, we propose a modified equation for the ICME motion.

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