Work Group 2: Theory

Progress report (Sept. 2017-…)

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Brief History

- kick-off meeting of the ISEST program: June 2013, Hvar Observatory, Croatia
- four groups were defined, which became a backbone of the ISEST program:

✓ WG1: Data
✓ **WG2: Theory**
✓ WG3: Simulation
✓ WG4: Event Campaign

(Later on, three more groups were added: WG5 Bs Challenge, WG6 Solar Energetic Particles, WG7 MiniMax Campaign)

The Overall Aim and Goals of WG2

The overall aim of WG2 is to advance our comprehension of the physical background of Earth-affecting solar transients

The main goals are:

- to improve our understanding of the structure and evolution of CMEs, including magnetic flux ropes and driven shocks, as well as their origin;
- to improve comprehension of coronal/heliospheric dynamics of CMEs, including the interaction with ambient solar wind and interplanetary magnetic field, causing deceleration/acceleration and deflections;
- to get a better insight into how long does the Lorentz force dominate over the aerodynamic drag force, including the estimation of the drag parameter and/or the dimensionless drag coefficient;
- to improve our capability in modelling and forecasting the southward magnetic field component (Bs) inside a CME;
- to compare the theoretical results with observations, e.g., 1 AU transit time, impact speed, impact magnetic field, etc.;

Workshops Related to WG2

- 2013 06 17-20: Hvar, Croatia ("kick-off")
- ……
- **2017 09 18-22: Jeju Island, Korea**
- 2017 09 25-29: Our Mysterious Sun: Coupling Between Solar Interior and Atmosphere, Tbilisi, Georgia
- 2017 12 11-15: AGU Fall Meeting, New Orleans, USA (several sessions)
- 2018 01 7-13: Fundamental Physical Processes in Solar-Terrestrial Research and Their Relevance to Planetary Physics 2018, Kona, Hawaii, USA
- 2018 04 08-13: EGU Vienna, (several sessions)
- 2018 07 14-22: 42nd Scientific Assembly of COSPAR, Pasadena, California, USA
- 2018 07 9-13: SCOSTEP 14th Quadrennial Solar-Terrestrial Physics Symposium, Toronto, Canada
- ??
- 2018 09 24-28: Hvar

Activities

- Pre-eruptive phase: energy build-up, flux-rope formation, role of emerging flux, …
- Eruption onset: processes leading to loss of equilibrium, MHD instabilities, …
- Low-coronal evolution of eruptions: impulsive/gradual CME acceleration, role of flare-related reconnection, mass loading, shock formation and evolution, drag effects, deflections, rotation
- Heliospheric propagation: drag-effects, deflections, rotation, CME-shock relationship (offset,…), forecasting methods/models, Forbush decrease
- CIR-related issues
- ……

Topical Collection on Earth-affecting Solar Transients (J. Zhang, X. Blanco-Cano, N. Nitta, N. Srivastava, and C. H. Mandrini, **Solar Phys. 2018, 293, 80**)

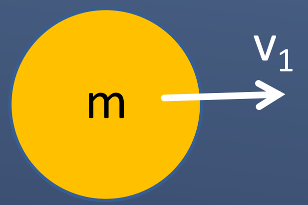
- Fitting and Reconstruction of Thirteen Simple Coronal Mass Ejections (Al Haddad et al. 2018 sph 293, 73)
- Forward Modeling of Coronal Mass Ejection Flux Ropes in the Inner Heliosphere with 3DCORE (Mostl et al. 2018 SpWea 16, 216)

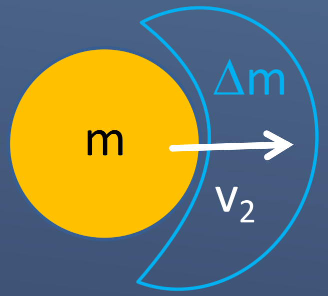
- Evolution of CME Mass in the Corona (Howard & Vourlidas 2018 sph 293, 55)
- Why the Shock-ICME Complex Structure Is Important: Learning from the Early 2017 September CMEs (Shen et al. 2018 ApJ 861, 28)
- Sheath-accumulating Propagation of Interplanetary Coronal Mass Ejection (Takahashi & Shibata 2017 ApJL 837, L17)
- Compressible Flow in Front of an Axisymmetric Blunt Object: Analytic Approximation and Astrophysical Implications (Keshet & Naor 2016 ApJ 830, 147)
- Which Bow Shock Theory, Gasdynamic or Magnetohydrodynamic, Better Explains CME Stand-off Distance Ratios from LASCO-C2 Observations ? (Lee et al. 2017, ApJ, 838, 70)

- Flux Rope Formation Due to Shearing and Zipper Reconnection (Threlfall et al. 2018 sph 293, 98)
- Buildup of a highly twisted magnetic flux rope during a solar eruption (Wang et al. 2017, NatComm 8, 1330)

- On the Collision Nature of Two Coronal Mass Ejections: A Review (Shen et al. 2017 sph 292, 104)
- .....

Example: CME-Shock System & Fast-CME Deceleration





$$m\,v_1 = (m + \Delta m)\,v_2 \quad \Rightarrow \quad v_2 < v_1$$

$$m\,\partial v/\partial t = -v\,\partial m/\partial t$$

$$\partial m/\partial t = A\,\rho_{sw}\,v \quad \text{(solar wind frame)}$$

$$f = 0 \quad \Rightarrow \quad \partial(mv)/\partial t = 0$$

$$v\,\partial m/\partial t + m\,\partial v/\partial t = 0$$

$$m\,a = A\,\rho_{sw}\,v\,v$$

Rest frame: $v = V - w$

$$a = -\gamma\,(V - w)^2 \qquad (\gamma = A\rho_{sw}/m)$$

drag: $a = -\gamma\,(V - w)\,|V - w|$

THANK YOU !