Introduction to the Physics of the Sun, Heliosphere and Space Weather

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Abstract

The Sun is the prime source of energy in our solar system and it is the prime source of space weather. Although its energy release at visible wavelengths of the electromagnetic spectrum is fairly constant in time, other forms of energy output vary substantially on various spatial and time-scales by orders of magnitude. These forms of solar variability manifest themselves in different physical processes in interplanetary space and have different consequences for the celestial bodies in the region of space affected. The fundamental principles of these processes have been unravelled through successful operation of dedicated space missions over the past decades. Today missions like STEREO, SDO, Proba2, ACE and Wind, to name some prominent ones, a fleet of spacecraft in the inner heliosphere allows us to analyze the physics of the Sun-Earth system in an unprecedented manner. Quantification of space weather processes is the crucial near-term path to help establish reliable space weather operational forecast systems. New activities of the EU and ESA programs currently foster projects that aim at mitigating harmful effects on state-of-the-art technological systems that have become essential to modern society, such as GPS systems. These activities are timely because many modern technology are vulnerable to space weather effects, comparable to the problems generated by the electrical currents induced in telegraph lines during strong geomagnetic storms, e.g., during the famous Carrington event in 1859.

This opening lecture will provide an interdisciplinary review on how the field of space weather has historically developed from solar-terrestrial physics and it will introduce the basic definitions and physics principles in solar and heliospheric physics that are fundamental for the main space weather processes. This introduction will provide baseline knowledge for the following detailed lectures on current theories, models and simulation methods on the different physical layers and coupling mechanisms of the Sun-Earth system, and for the broad range of subjects ranging from space weather data analysis, application of tools, instrumentation and mission development, forecasting methods, existing infrastructures and assets to upcoming projects and activities that will be held the next two weeks by prominent lecturers at this “International Advanced School on Space Weather Modelling and Applications” at the Trieste Centre for Theoretical Physics.

Date: Monday 18 October 2010
Time: 14:00-17:00
Room: Kastler Lecture Hall @ Adriatico Guest House

Dr. Volker Bothmer

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Curriculum vitae

(* July 16.1961). 1981-1989 Studies in Physics, University of Göttingen. 1989 Diploma in Phyiscs, University of Göttingen. 1993 Dr. rer. nat. in Physics, University of Göttingen as Max-Planck-Society Scholarship at MPI for Aeronomie, Katlenburg-Lindau. 1993-1994 Post-Doctoral Fellowship at MPI for Aeronomie, Katlenburg-Lindau. 1994-1996 ESA Research Fellow at ESA/ESTEC, Noordwijk, The Netherlands. 1996-2001 Research Scientist at University of Kiel. 2001-2004 Project Lead of Stereo/Corona at MPI for Solar System Research, Katlenburg-Lindau. Since 2005 Project Lead for Stereo/Corona, Institute for Astrophysics, University of Göttingen.

Professional Expertise (Selected)

2010 Lead of AFFECTS project selected by EU for funding 2010-2013 within the FP7 framework. Co-Investigator on several proposal related to the ESA SSA programme ITTs, e.g., as lead of international instrument consortium for "Implementation Design Study of Space Weather Instrumentation" submitted to ESA by Astrium GmbH Friedrichshafen and University Göttingen, currenbtly in negotiation phase with ESA. Co-Investigator of "Wide-field Imager for Solar PRobe (WISPR)" submitted to NASA by NRL, Washington, D.C., the NASA Solar Probe Plus AO.

2009 Co-Investigator on the Heliospheric Imager for the Solar Orbiter Mission (SoloHI), preselected for the payload of the ESA Solar Orbiter Mission.

2008 Project Lead lead of WP3 EU FP7 SOTERIA (SOlar-Terrestrial Investigations and Archives).

2006 Lead Editor "Space Weather – Physics and Effects", Springer/Praxis.

2006 Lead Editor "Solar Variability and its Magnetic Origin" (IAUS 233), Proceedings of the International Astronomical Union Symposia and Colloquia, Cambridge University Press.

2005 Member of the Science Consortium for SWAP and LYRA (SCSL) for ESA's Proba 2 mission launched in 2009.

2004 NASA Solar Probe Science & Technology Definition Team

2001 Project Lead Stereo/Corona.

1999 Co-Investigator on the Sun Earth Connection and Heliospheric Investigation (SECCHI) and the In-situ Measurements of Particles and CME (Coronal Mass Ejection) Transients (IMPACT) for the NASA STEREO Mission launched 2006.

1996 NASA STEREO Science Definition Team.

Member of IAU, EGU, AGU and EGU solar physics secretary (since 1999), Co-Chair of COSPAR Sub-Commission D2/E3 (since 2004).

Referee for JGR Space Physics Section, Solar Physics, Advances Space Res., Annales Geophysicae, Journal of Atmospheric and Terrestrial Physics (JATP), Astronomy and Astrophysics, Astrophysical Journal, Geophysical Research Letters, AGU Space Weather, AGU book series, Astrophysics and Space Science, Ed. Boards: Springer/Praxis, Betham Open "The Open Plasma Physics Journal", Space Weather: The International Journal of Research and Applications (AGU). Peer reviews for NSF, Swedish Space Board, ESA, various Universities, NASA.

Awards

NASA "STEREO Group Achievement Award" for outstanding work in the design, development, test, and launch of the STEREO twin Observatories which image the Sun in 3-D; 08-May-2008.

Annual Alan Berman Research Award, Naval Research Laboratory, Washinton, D.C., October 2008, Sun Earth Connection Coronal and Heliospheric Investigation (SECCHI).

Main fields of research

Solar and heliospheric physics, space plasma physics, solar energetic particles, cosmic rays, physics of the earth's magnetosphere and ionosphere, science and technology studies of future space missions and instrumentation. Prime focus: Physics of coronal mass ejections and their impact on the heliosphere, especially on geo-space and their space weather effects.

Selected publications (10 since 2004)

1. Nisticò , G., **V. Bothmer** , S. Patsourakos, G. Zimbardo, Observational features of equatorial coronal hole jets, Ann. Geophys., 28, 1–10, 2010.

2. Messerotti, M., Zuccarello, F., Guglielmino, S.L., **Bothmer, V.**, Lilensten, J., Noci, G., Storini, M., Lundstedt, H., SolarWeather Event Modelling and Prediction, Space Sci. Rev., DOI 10.1007/s11214-009-9574-, 2009.

3. Howard, R.A., J.D. Moses, A. Vourlidas, J.S. Newmark, D.S. Socker, S.P. Plunkett, C.M. Korendyke, J. C. Cook, A. Hurley, J. M. Davila, W. T. Thompson, O.C. St Cyr, E. Mentzell, K. Mehalick, J.R. Lemen, J.P. Wuelser, D.W. Duncan, T.D. Tarbell, R. A. Harrison, N. R. Waltham, J. Lang, C.J. Davis, C.J. Eyles, J.P. Halain, J.M Defise, E. Mazy, P. Rochus, R, Mercier, M. F. Ravet, F. Delmotte, F. Auchere, J.P. Delaboudiniere, **V. Bothmer**, W. Deutsch, D. Wang, N. Rich, S. Cooper, V. Stephens, G. Maahs, R. Baugh, D. McMullin, Sun Earth Connection Coronal and Heliospheric Investigation (SECCHI), *Space Sci. Rev.*, Vol. 136, doi: 10.1007/s11214-008-9341-4, 2008.

4. Aschwanden, M., Antiochos, S.K., J.W. Cook, R.A. Howard, J.T. Karpen, J.A. Klimchuk, N.R. Sheeley, L.A. Fisk, T.I. Gombosi, N. Lugaz, W.I.V. Manchester, I.I. Roussev, T.H. Zurbuchen, L.F. Burlaga, M.L. Kaiser, C.K. Ng, D.V. Reames, M.J. Reiner, C.J. Farrugia, A. Galvin, M.A. Lee, J.A. linker, Z. Mikic, P. Riley, D. Alexander, A.W. Sandman, E. De Jong, P.C. Liewer, D. Odstrcil, V. Pizzo, J. Luhmann, B. Inhester, R.W. Schwenn, S. Solanki, V.M. Vasyliunas, T. Wiegelmann, J.-L.H. Bougeret, M. Maksimovich, J.-L. Steinberg, I.H. Cairns, P.A. Robinson, H. Kunow, R. Wimmer-Schweingruber, P.A. Lamy, A. Llebaria, P. Bochsler**, V. Bothmer**, K. Kecskemety, J. Kota, M. Scholer, Theoretical Modeling for the STEREO Mission, *Space Sci. Rev.*, *Space Sci. Rev.*, Vol. 136, doi: 10.1007/s11214-006-9027-8, 2008.

5. **Bothmer, V.**, The Sun as the prime source of space weather, in "*Space Weather – Physics and Effects*", Eds. V. Bothmer and Y. Daglis, Springer/Praxis, 2007.

6**. Bothmer, V.**, and Tripathi, D., Evolution of the photospheric magnetic field in the source regions of coronal mass ejections, Modern Solar Facilities – Advanced Solar Science, F. Kneer, K. G. Puschmann, A. D. Wittmann (eds.), Universitätsverlag Göttingen, 257-260, 2007.

7. Tripathi, D.K., S.K. Solanki, R. Schwenn, **V. Bothmer**, M. Mierla, G. Stenborg, Observation of a bright coronal downflow by SoHO/EIT, *Astronomy and Astrophysics*, 449, 369-378, 2006.

8. Forsyth, R.J., and **Bothmer, V.**, Co-Chairs, Cid, C., Crooker, N.U., Horbury, T.S., Kecskemety, K., Klecker, B., Linker, J.A., Odstrcil, D., Reiner, M.J., Richardson, I.G., Rodriguez-Pacheco, J., Schmidt, J.M., Wimmer-Schweingruber, R.F., ICMEs in the inner heliosphere: Origin, evolution and propagation effects, Report of WG G, *Space Sci. Rev.*, 123, 1-3, 2006.

9. Cremades, H., **V. Bothmer**, D. Tripathi, Properties of Structured Coronal Mass Ejections in Solar Cycle 23, *Adv. Space Res.*, 38, 3, doi:10.1016/j.asr.2005.01.095, 461-465, 2006.

10. Huttunen, K.E.J., R. Schwenn, **V. Bothmer**, and H.E.J. Koskinen, Properties and geoeffectiveness of magnetic clouds in the rising, maximum and early declining phases of solar cycle 23, Annales Geophysicae, 23, 1-17, 2005.