CURRICULUM VITAE

Prof. Marco Velli
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University and Research Appointments

2014 - present Professor, Space Physics, University of California, Los Angeles

2007 - present Senior Research Scientist, Jet Propulsion Laboratory, Cal. Inst. of Technology, Pasadena

2004 - 2007 Principal Scientist, Jet Propulsion Laboratory, Cal. Inst. of Technology, Pasadena

1998 - 2014 Associate Professor of Astronomy, Department of Physics and Astronomy, University of Florence

1993 - 1998 Research Scientist, Department of Astronomy and Space Science, University of Florence

Post-doctoral Experience

1992-1993 Ministere Recherche et Tecnologie Fellow, Departement de Recherche Spatiale, Observatoire de Paris (Research Director '89-'93: André Mangeney)

1991-1992 NATO Advanced Research Fellow, Departement de Recherche Spatiale, Observatoire de Paris

1989-1991 Post-doctoral Research Fellow, **ESA**, held at the Departement de Recherche Spatiale, Observatoire de Paris

Research topics (1989-1993): propagation of magnetohydrodynamic (MHD) waves in the solar corona and wind, MHD turbulence in an expanding medium. I studied the effects of the large-scale spatial gradients, due to the solar wind expansion, on the development of MHD turbulence in the solar wind and its relation with the stream structure and thermodynamic properties of the wind. Developed the first model of reflection-driven turbulence for the solar corona and wind.

1985-1989 Postdoctoral Research Assistant, Solar Physics group, Department of Mathematics, University of St.Andrews, Scotland (Research Directors: Eric Priest, Alan Hood)

Research topics (1985-1989): small and large-scale instabilities of solar flux-tubes and coronal loops, with the aim of understanding energy storage and release in solar flares. I calculated growth rates for the tearing and kink-mode instabilities taking into account the photospheric line-tying effect on the coronal magnetic field.

Education

1985 Diploma di laurea: Doctor in Physics, University of Pisa (110/110 cum laude) and Diploma in Physics, Scuola Normale Superiore

Thesis subject: plasma physics. The thesis developed a model for the "fishbone" instabilities observed in nuclear fusion experiments of the tokamak type when an energetic neutral particle beam is used as an auxiliary heating source in addition to standard Ohmic heating.

1980-1985 "Corso di Laurea" in Physics, Faculty of Mathematical, Physical, and Natural Sciences University of Pisa, Italy
1980-1985 Fellowship in the Class of Sciences, Scuola Normale Superiore, Pisa, Italy

Prizes/Fellowships

I was elected **AGU fellow** (Space Physics and Aereonomy) for "For pioneering work on coronal heating, the origin of the solar wind, and the theory of solar wind turbulence driven by wave reflections." at the AGU Fall meeting December 2014.

Mission Proposals

PI Solar Probe Plus Observatory Scientist (Heliospheric Origins with Solar Probe Plus) 2010-2024
Co-I (USA) on investigations for the **Solar Orbiter** mission: **Magnetometer** (PI Tim Horbury, Imperial, London), **Hemispheric Imager** SOLO-HI (NRL), the combined **Coronograph – Ultraviolet spectrometer METIS** (Florence and Torino, Italy), and the **RPW**: Radio and Plasma Waves (**Meudon) 2019 – 2025**

PI of a **NASA Explorer Call Mission SAFARI:** Solar Activity Far Side Investigation, a mission to explore the relationship between solar activity and the solar dynamo, which was rated Category II, i.e. potentially fundable and viable with no major technology developments (2011). For this mission proposal we worked closely with the industrial partner and spacecraft provider Orbital ATK, where we planned a secondary solid rocket booster to allow this to become the first Explorer mission to leave Earth orbit and obtain stereoscopic measurements of the solar and magnetic field, allowing a better understanding of the solar core via helioseismology as well the development of solar activity and the dynamo.
Co-PI for the **ESA Cosmic Visions** proposal **PHOIBOS: Probing Heliospheric Origins with and Inner Boundary Observing Spacecraft** (2007). This mission planned a Jupiter encounter and a polar orbit to reach a perihelion of 4 solar radii from the center of the Sun.
Co-PI of an ASI (Italian Space Agency) small mission **ADAHELI** (Advanced Astronomy for heliophysics – Selected for phase A study before the ASI small mission program was cancelled) (2008: http://adsabs.harvard.edu/abs/2008ESPM...12..6.6B).

As a a consultant, I spend 1 day/wk at JPL where I am the Heliophysics HQ Liason manager as well as the Heliosphysics Program Office Expert advising on JPL proposals to Heliophysics. I helped manage and review the successful **(2017)** Mission of Opportunity Proposal **SunRISE** - Sun Radio Interferometer Space Experiment – It will consist of a ***constellation of cubesats*** operating as a synthetic aperture radio telescope to address the critical heliophysics problems of how solar energetic particles are accelerated and released into interplanetary space. PI Justin Kasper, Michigan.

Peer Review Committees, Mission Science Definition Teams, Advisory Councils

2012-2016 ISSI International Space Science Studies Institute, Bern, Science Committee
2010-2012 ESA SSEWG - European Space Agency Solar System and Exploration Working Group: took part in the discussion and presentations of missions for Cosmic Visions L1
2010-2012 Member of the Theory and Modeling group for the NRC Space Physics Decadal Survey
2008-2010 Solar Orbiter Redefinition team. When Solar Orbiter re-entered the Cosmic Visions

competition, was co-lead of a tiger team to get the proposal ready for the M1 selection competition. After selection and with NASA's confirmation of what is now the Parker Solar Probe, participated in an advisory "Tiger" team to define viability of SO science as a lone-standing mission as well as possible synergies in the light of Solar Probe.

I presented the science case for Solar Orbiter at the ESA Cosmic Vision M-Class Missions Presentation Event, December 1st, 2009.

2004-2008, Solar Probe Science and Technology Definition Team, responsible for coordinating and drafting Scientific Objectives of the mission.

2003-2005 Member, Solar Orbiter Science Definition Team

I have been a member of, as well as chaired, peer review committees for NASA research as well as mission payload proposals. I was also a member of the Italian Space Agency (ASI) Solar System Working Group through 2013.

For a more detailed discussion of my activities in conjunction with ESA and NASA, please see my Statement of Interest/Cover Letter.

Research Proposals Funded – USA

2010-2024 "Heliospheric Origins with Solar Probe Plus", PI (**Solar Probe Plus Observatory Scientist)**
2017-2020 Heliophysics Grand Challenges Research, Nonlinear Dynamics of Closed and Open Regions Driven by Footpoint Shuffling: Coronal Heating and Wind Formation and Acceleration, R.Dahlburg, PI
2012-2016 "Multi-temperature coronal loop structures from field-line tangling and turbulent dissipation: simulations and diagnostics." M. Velli PI, F. Rappazzo Co-I, R.Dahlburg, co-I, G. Einaudi, Co-I
2008-2013 "The Structure and Dynamics of the Solar Corona and Inner Heliosphere" NASA Heliophysics Theory Program, Co-I, Z. Mikic, SAIC, PI (renewed twice)
2009-2012 "Magnetohydrodynamics of Coronal and Solar Wind Heating: Closed and Open Field Regions." PI, F. Rappazzo Co-I, R.Dahlburg, co-I
2008-2010 "The spatial and temporal variability of the solar wind: an mhd investigation", Co-I, R. Lionello, SAIC, PI
2006-2008 "Towards a global 3D MHD solar wind model with realistic energy flux: tracing the turbulent energy flow from the photosphere to the corona and beyond" NASA LWS, TR&T, PI, M. Opher, George Mason, Co-I
2006-2008 "MHD turbulence heating of the magnetically confined solar corona" NASA – Sun Earth Connection SR&T, PI, R.Dahlburg, J. Klimchuk, NRL, G. Einaudi, George Mason, Co-Is.
2002-2005 "Investigation of solar wind heating and acceleration: Wave-particle interaction mechanisms." NASA SR&T**,** Co-I, B. Goldstein, JPL, PI

JPL Internal Funding

2015-present Research &Technology Development Estimating Science Yield from SAFARI and other candidate Helioseismology missions
2013-2014 Research &Technology Development Strategic Proposal SAFARI Solar Activity Far Side Investigation;

2005-2008 Research &Technology Development Strategic Interdisciplinary proposal on accretion disks, planetary formation and the development of prebiotic conditions
2005-2007 Director's Research Discretionary Fund Numerical simulations of the solar wind

Research Proposals Funded - Italy and Europe

2012-2016 European Union Research and Training Network SHOCK "*Solar and heliospheric collisionless kinetics: enabling data analysis of the sun to earth plasma*" " PI Univ. of Florence
2002-2006 European Union Research and Training Network **"***Theory, Observation and Simulation of Turbulence In Space Plasmas*" University of Florence coordinator (CO-PI), PJ Cargill, Imperial College, PI.
Italian Ministry of Research Inter-University projects: 2002-2004 PI, proposal on "*Waves, turbulence, dissipation and particle acceleration in the solar atmosphere and interplanetary space*", was **ranked first** in all of the Physical Sciences. **1994-2002** CO-I

Referee, Tenure Committees

I have served as referee for JGR, ApJ, PRL, Physics Letters, Physics of Plasmas. I was on the tenure committee for N Schwadron (U. New Hampshire) G. Howes (U. Iowa) and selection committee for the University of Oslo (2009) for B. Gudiksen. Internally, in EPSS at UCLA, I served on the promotion review committee for V. Angelopoulos, and am currently a member of the teaching committee.

Visiting Appointments

October 1992 - Harvard Smithsonian CFA, Visiting Scientist (with S.R. Habbal)
January 1993 – **June 1993** Dipartimento di Fisica, Università della Calabria (with P-L. Veltri)
October 1994- Harvard Smithsonian CFA, Visiting Scientist (with S.R. Habbal)
February-October 1998 NASA NRC Senior Research Associate, Jet Propulsion Laboratory, Space Science Department (collaboration with B.E. Goldstein P.C. Liewer and M. Neugebauer)
November-December 1998 Institut d'Astrophysique Spatiale, Orsay (with J.C. Vial, A. Gabriel)
August-September 1999, August 2000, August 2001, August 2002, Jet Propulsion Laboratory, Space Science Department (collaboration with B.E. Goldstein P.C. Liewer and M. Neugebauer, no-fee consultant)
January 2003 – October 2003 NASA NRC Senior Research Associate, Jet Propulsion Laboratory, Space Science Department collaboration with B.E. Goldstein and P.C. Liewer
March 2005 – June 2005 Institute for Pure and Applied Mathematics, UCLA, school on Grand Challenge Problems in Computational Astrophysics. Resident researcher, conference organizer and invited speaker.

Invited Review papers were presented at the following conferences:

1990 British Theoretical Mechanics Colloquium, Symposium on Geophysical and Astrophysical Magnetohydrodynamics, St Andrews, Scotland,
1991 European Geophysical Society, Wiesbaden, Germany,
1**992** European Geophysical Society, Edinburgh, Scotland, First World Space Congress**,** Washington, DC
1993 MiniWorkshop "Wave Phenomena in Solar Terrestrial Plasma", Oslo, Norway,
1994 7th European meeting on Solar Phys., "Advances in Solar physics", Catania, Italy,
1995 Solar Wind Eight, Dana Point, CA; Cool Stars, Stellar Systems and the Sun, 9th Cambridge Workshop, Florence, Italy
1997 24th EPS Conference on Controlled Fusion and Plasma Physics, Berchetesgaden, Germany
1998 Solar Wind Nine, Martha's Vineyard, MA

2000 Les Rencontres de l'Observatoire "Physics of Space: Growth Points and Problems", Paris, Meudon
2001 American Geophysical Union Spring Meeting, Boston, European Geophysical Society Meeting, Nice, France, Solar Encounter: The First Solar Orbiter Workshop, Tenerife, Spain, SOLSPA Euroconference on Solar Cycle and Space Weather, Vico Equense, Naples, Italy
2003 30th EPS Conference on Controlled Fusion and Plasma Physics, St-Petersburg, Russia,
2005 Grand Challenge Problems in Computational Astrophysics, Astrophysical Fluid Dynamics, and culminating workshop, Lake Arrowhead, CA,
AIAA Conference, Laguna Beach, CA
2006 SOHO 17, 10 years of SOHO and beyond, Giardini Naxos, Italy, Coronal Heating and Solar Wind Acceleration, A meeting in honor of Joe Hollweg Durham NH, Second Solar Orbiter workshop, Athens, Greece
2007 International Heliophysical Year, 2nd European General Assembly, Torino, Italy, Space Plasmas and Astrophysics, International workshop in honor of André Mangeney, Meudon, France, and American Geophysical Union Fall Meeting, San Francisco.
2008 12th European Solar Physics Meeting, Freiburg, Germany American Geophysical Union Fall Meeting, San Francisco
2009 Modern Challenges in Nonlinear Plasma Physics, A meeting in Honor of Denis Papadopoulos, Sani, Greece, American Geophysical Union Fall Meeting, San Francisco
2010 Workshop on Spontaneous Energy Focusing Phenomena and Multiscale Physics, Julia Schwinger Institute of Theoretical Physics, Nanyang Technical University, Singapore, American Geophysical Union Fall Meeting, San Francisco
2011 European Geophysical Union Meeting, Vienna
2012 From the Heliosphere into the Sun - Sailing Against the Wind - A meeting dedicated to the progress of our understanding of the solar wind and the corona in the light of the upcoming Solar Orbiter mission. Physikzentrum Bad Honnef, Germany; Solar Wind Thirteen, Kona, Hawaii
2013, 2014, 2015 Fall American Geophysical Union meeting, San Francisco, CA, USA
2015, 2016 NSF SHINE (Solar, Heliospheric, and INterplanetary Environment) meetings, Stowe, VT, Santa Fe, NM, USA.
2017 Twentieth Anniversary meeting NSF/DOE partnership, Alexandria, Md, USA IPELS (Interrelationship between Plasma Experiments in the Laboratory and in Space) meeting, Rancho Bernardo, SD, CA

I was chair of SOC and LOC editor of the Solar Wind Ten conference held in Pisa in June 2002, refereed proceedings published by American Institute of Physics AIP 679 "Solar Wind Ten" Velli, Bruno, Malara Eds. I was also SOC member and chair of the First Solar Probe Plus workshop, Pasadena, 2013, and the First Joint Solar Probe Plus- Solar Orbiter meeting, Artimino, Florence, September 2-4, 2015

Teaching

1994-1998 U. Firenze: 1st Year Physics (Mechanics, Thermodynamics Fluid dynamics), Undergraduate, TA for Physics students,
1996-1998 U. Firenze: 1st Year Physics (Mechanics, Thermodynamics Fluid dynamics) Undergraduate **2nd Year Physics** (Electromagnetism and Optics) Undergraduate, for Students in Optics and Optometry.
1998-2005 U. Firenze: Physics (Mechanics, Thermodynamics, Fluid Mechanics, Electromagnetism) Undergraduate for Students in the Natural Sciences.
1998-2005 U. Firenze: General Astronomy Undergraduate, for Students in the Natural Sciences.
2003-2005 U. Firenze: High Energy Astrophysics Undergraduate, Final year elective Physics students.
2009-2013 U. Firenze: Astrophysics Graduate Course in Astrophysics.

2001-2013 U. Firenze: Plasma Astrophysics: Masters Final year students and PhD students (compulsory).
2014-2015 UCLA Winter EPSS 200C-254 Introduction to Introduction to Geophysics and Space Physics III: Plasmas - Solar Terrestrial Physics **Spring EPSS** Space Physics Journal Club and Space Physics Seminar Series
2015-2016 UCLA Fall Space Physics Journal Club and Space Physics Seminar Series; **EPSS 240** Space Plasma Physics; **Winter EPSS 156** Introduction to Space Plasma Physics.
2016-2017 UCLA Fall Space Physics Journal Club and Space Physics Seminar Series **EPSS 298** An Introduction to MHD Turbulence **EPSS Winter** Perils of Space: Introduction to Space Weather

I have also taught courses and published lectures for numerous summer schools in astrophysics and plasma physics, and co-directed the Italian National Astrophysics summer school in Trieste in October 2006 on Plasma Astrophysics and Galaxy Clusters (see publication list).

Research Direction, Master's and Graduate Level

Directed a number of ``Laurea Theses", more or less equivalent to Master's theses. Most recent were **S. Galligani** (Alfvén wave turbulence in molecular clouds) **F. Pucci** (Fast magnetic reconnection: ideal instabilities of thin current sheets). **F. Pucci** completed her PhD at U. of Rome under the direction of myself and Prof. F. Berrilli and is currently a post-doctoral researcher with a joint Princeton Plasma Physics Lab., Princeton University, and National Institute of Fusion Science, Japan appointment. Directed or co-directed 10 Doctoral theses, two combined PhD between the university of Paris and Florence. One of my students, **L. Del Zanna** is a tenured researcher in Firenze, **R. Lionello**, works as Research Scientist for SAIC in San Diego. Another**, E. Buchlin**, is a tenured scientis at CNRS in Orsay, **A. Verdini** has a tenure track researcher position at the University of Florence, **L. Bettarini** holds a post-doc at the Katholieke Universiteit Leuven while **F. Rappazzo** is an assistant researcher at UCLA. **L. Matteini** has a tenured astronomer position at the Observatoire de Paris-Meudon. **x**

I am presently advising two PhD students at UCLA both at the end of their second year: **Chen Shi**, working on magnetic reconnection and Alfvén wave turbulence in the solar corona and wind; **Steve Tomlinson**, working on the structure and stability of solar filaments and prominences.

In the years 1999-2003 I served as a permanent member on the University of Florence doctoral examination committee, as well as coordinator of the Astrophysics PhD program at the Department of Physics, and Astrophysical Observatory, Florence. I've served as examiner, or referee, for a number of PhD candidates within Europe : M. Maksimovic, 1997, K. Issautier 1998, S. Landi, 2001, University of Paris,, D. Laveder, 2001 University of Nice, I. Zouganelis, University of Paris 2005, R. Pinto, University of Paris, 2011, Y. Dong, Ecole Polytechineque, 2013.

A Synopsis of My Research Work

A. Tenerani, M. Velli (2016). Evolving Waves and Turbulence in the Outer Corona and Inner Heliosphere: The Accelerating Expanding Box, Astrophys. J. 843, 1, a.id. 26,

This paper provides a model to study Alfvénic fluctuations in the solar wind in the acceleration region in a periodic simulation box. Alfvénic turbulence displays many properties reflecting an ongoing nonlinear cascade, e.g., a well-defined spectrum in frequency, together with some characteristics more commonly associated with the linear propagation of waves from the Sun, such as the variation of fluctuation amplitude with distance, dominated by solar wind expansion effects.

Therefore, both nonlinearities and expansion must be included simultaneously in any successful model of solar wind turbulence evolution. Because of the disparate spatial scales involved, direct numerical simulations of turbulence in the solar wind represent an arduous task, especially if one wants to go beyond the incompressible approximation. Indeed, most simulations neglect solar wind expansion effects entirely. Here we develop a numerical model to simulate turbulent fluctuations from the outer corona to 1 au and beyond, including the sub-Alfvénic corona. The accelerating expanding box (AEB) extends the validity of previous expanding box models by taking into account both the acceleration of the solar wind and the inhomogeneity of background density and magnetic field. Our method incorporates a background accelerating wind within a magnetic field that naturally follows the Parker spiral evolution using a two-scale analysis in which the macroscopic spatial effect coupling fluctuations with background gradients becomes a time-dependent coupling term in a homogeneous box. In this paper we describe the AEB model in detail and discuss its main properties, illustrating its validity by studying Alfvén wave propagation across the Alfvén critical point.

F. Pucci, M. Velli (2014). Reconnection of Quasi-Singular Current Sheets: the "Ideal" Tearing Mode. Astrophys. J. Letts. 780 (2), L19

This paper showed that the Sweet Parker current sheet can not form in high Lundquist (S) value natural plasmas by showing that an "ideal" tearing mode takes over before current sheets reach such thicknesses. While the Sweet-Parker current sheet thickness scales as $\sim S^{-1/2}$, the tearing mode becomes effectively ideal when a current sheet collapses to a thickness of order $\sim S^{-1/3}$, up to 100 times thicker than $S^{-1/2}$ when, as happens in many astrophysical environments, S is as large as 10^{12}. Such a sheet, while still diffusing over a very long time, is unstable to a tearing mode with multiple x-points. This paper has now been cited over 40 times and is becoming a standard reference on fast Reconnection instabilities in plasmas.

A. Verdini, R. Grappin, M. Velli (2012). On the origin of the 1/f spectrum in the heliosphere. THE Astrophys. J., 750, p. 13293-13297 .

A mechanism for the formation of the low-frequency 1/f magnetic spectrum based on numerical solutions of a shell-reduced MHD model of the turbulent dynamics inside the sub-Alfvénic solar wind is presented and discussed. Realistic profiles of wind speed and density along a radial magnetic field are assigned. Alfvén waves of short periodicity (600 s) propagating from the base of the chromosphere penetrate into the corona and are partially reflected triggering a turbulent cascade. The cascade is strong for the reflected wave while it is weak for the outward propagating waves. Reflection at the transition region recycles the strong turbulent spectrum into the outward weak spectrum, which is advected beyond the Alfvénic critical point without substantial evolution. There, the magnetic field has a perpendicular power-law spectrum with slope close to the Kolmogorov -5/3. The parallel spectrum is inherited from the frequency spectrum of large (perpendicular) eddies. The shape is a double power law with slopes of ~= - 1 and -2 at low and high frequencies, respectively, with the position of the break depending on the injected spectrum. We suggest that the double power-law spectrum measured by Helios at 0.3 AU, where the average magnetic field is not aligned with the radial (contrary to our assumptions), results from the combination of such different spectral slopes. At low frequency the parallel spectrum dominates with its characteristic 1/f shape, while at higher frequencies its steep spectral slope (-2) is masked by the more energetic perpendicular spectrum (slope -5/3).

Rappazzo, F., Velli, M. Einaudi, G. and Dahlburg, R. (2007) Astrophys J. , 657, L47, Coronal

Heating, Weak MHD Turbulence, and Scaling Laws..

In this paper we solved the Parker coronal heating model, which invoked field line tangling as a source for coronal heating extending the previous 2D work of einauti et al. 1996. We obtained closed form solution via a number of numerical simulations followed by a non-linear phenomenological model which obtains all previously reported scaling laws and predicts the heating rate as a function of photospheric velocity, magnetic field strength and loop aspect ratio. Strong turbulence is found for weak axial magnetic fields and long loops, leading to Kolmogorov-like spectra in the perpendicular direction, while weaker and weaker regimes (steeper spectral slopes of total energy) are found for strong axial magnetic fields and short loops. I consider this paper to be a major advance in our understanding of coronal heating processes. Indeed Prof. Parker himself was subsequently sufficiently convinced to work on some of the specific details, e.g. the amplitude of the transverse field reuiqred to trigger the non-linear cascade, to collaborate in his last two published papers with my ex-student F. Rappazzo.

Landi, S, Velli, M. Einaudi, G. (2005) ApJ 624, 392, "Alfvén Waves and Shock Wave Formation at an X-Point Magnetic Field Configuration"

We showed how Alfvén waves approaching generic threaded x-point topologies in a magnetic field naturally couple to fast waves and generate shocklets efficiently. In a periodic geometry the shocks intersect to form "cat's cradle" configurations, while in open boundaries the shock configurations resemble snow-flakes. Such ensembles of shocks could efficiently produce seed particle and accelerate populations in flares on the sun and other stars.

Liewer, P.C., Velli, M., Goldstein, B. E. (2001), JGR, 106, A12, 29261, "Alfvén wave propagation and ion cyclotron interactions in the expanding solar wind: One-dimensional hybrid simulations" and Hellinger, P., Velli, M., Travnıcek, P., Gary, S.P., Goldstein, B.E. Liewer, P.C., (2005) JGR, 110 A12109, doi:10.1029/2005JA011244 Alfvén wave heating of heavy ions in the expanding solar wind: Hybrid simulations"

We extended the Expanding Box Model to scales appropriate to the dissipation of Alfvén waves in the solar wind, via a hybrid particle code (ions treated kinetically, electrons as a fluid). Studied the ion-cyclotron resonance as a dissipation mechanism in the expanding solar wind. Research initiated here lead to collaborations with researchers from the Czech republic and to a PhD thesis project for a student nearing completion at the present time. It has also become a standard reference in coronal heating and minor ion studies.

Einaudi, G., Velli, M. Politano, H and Pouquet A. (1996) Ap J 457, L113 "Energy release in a turbulent corona"

We carried out the first long term simulations of forced turbulence in a coronal loop and showed how the resulting bursty behavior was analogous to the observed intermittency in solar flares and heating. This paper was the first to develop the idea that the power laws in flare spectre could be due to MHD turbulence dissipation. It has become a standard reference in coronal heating studies.

Velli, M. (1994) Astrophys. Journal 432, L55, "From supersonic winds to accretion: comments on the stability of stellar winds and related flows"

This paper for the first time gives a comprehensive discussion of the Parker solar wind theory in relation to the question of spherical accretion (described by exactly the same equations, Bondi,

1952) and proves why the solar wind is necessarily supersonic (albeit 30 years late, correcting misunderstandings in Parker's series of papers) or would otherwise be subject to accretion. It also points out how the transition from accretion to winds and back is necessarily catastrophic in nature, breezes and subsonic flows being quite generally unstable. This paper predicted a hysteresis cycle in such flows as the boundary conditions are varied, and explained a number of contradictory claims in the literature. A numerical simulation of the predictions contained in this paper (Del Zanna, Velli and Londrillo 1998) confirmed the nonlinear scenario presented here. I consider this paper to be one of my more original and accomplished results, though it is not heavily cited, it is the focus of an entire chapter of N. Meyer's book "Basics of the Solar Wind", Cambridge 2007 and of E. Priest's book "Magnetohydrodynamics of the Sun". It was also the subject of an invited talk at a special meeting in honor of Eugene Parker at the APS 50th Division of Plasma Physics, Dallas, Texas, 2008, Miniconference on the Plasma Physics of the Solar Wind: from Parker (1958) to the Present.

Grappin, R., Velli, M. and Mangeney, A., (1993) Phys. Rev. Letts., 70, 2190, "Nonlinear Wave Evolution in the Expanding Solar Wind" and Grappin, R. and Velli, M. (1996) JGR, 101, 425, "Waves and streams in the expanding solar wind"

We introduced the Expanding Box Model for studying the evolution of turbulence in the presence of structures such as high and low speed streams as well as the overall solar wind expansion. This allows the use of a standard periodic spectral code simulation without requiring a full Eulerian wind tunnel. The full exploitation of this model is still going on today with applications ranging from Alfvenic turbulence to magnetic holes in the solar wind.

Velli, M., (1993) Astronomy & Astrophys., 270, 304 "On the Propagation of Ideal, Linear Alfvén Waves in Radially Stratified Stellar Atmospheres and Winds"

I critically discussed the problem of the propagation and reflection of Alfvén waves in stratified atmospheres, developing an approximate analytical technique via time-ordered integrals and reconciling various contradicting results in the literature. The paper also disputed the notion that alfvén waves could be totally reflected in the corona, but suggested that reflection may play a role in the non-linear cascade and the development of turbulence in the solar wind. Paper was quoted as a major advance in the Advances in Astrophysics 2004 review paper and has become a standard reference.

Velli, M., Einaudi, G. and Hood, A.W., (1990) Astrophys. Journal 350, 418, "Boundary Effects on the MHD Stability of a Resistive Plasma"

In this paper we studied the effects of photospheric line-tying on the loss of stability of coronal magnetic structures. We developed a new method to include these effects via a Fourier analysis allowing non-periodic boundary conditions. We stressed how a boundary layer would naturally form with strong heating at the corona-photosphere interface (this appears to be directly related to the TRACE-observed moss). The numerical technique was later incorporated into standard numerical stability analysis codes for both Lab and Astrophysical plasmas.

"Per aspera ad astra"
"Sapere aude"

Publications – Marco Velli

Papers in refereed journals

1) Velli, M. and Hood, A.W., (1986) Solar Phys. 106, 353 “Resistive Ballooning Modes in Line-tied Coronal Fields: I. Arcades.”

2) Velli, M. and Hood, A.W., (1987) Solar Phys. 109, 351 “Resistive Ballooning Modes in Line-tied Coronal Fields: II. Loops.”

3) Velli, M. and Hood, A.W., (1989) Solar Phys. 119, 107 “Resistive Tearing in Line-tied Magnetic Fields: Slab Geometry.”

4) Velli, M., Grappin, R. and Mangeney, A., (1989) Phys. Rev. Letts. 63, 1807, “Turbulent Cascade of Incompressible, Unidirectional Alfv´en Waves in the Interplanetary Medium”

5) Velli, M., Einaudi, G. and Hood, A.W., (1990) Astrophys. Journal 350, 418, “Boundary Effects on the MHD Stability of a Resistive Plasma”

6) Velli, M., Einaudi, G. and Hood, A.W., (1990) Astrophys. Journal 350, 428, “Ideal Kink Instabilities in Line-tied Coronal Loops: Growth Rates and Geometrical Properties”

7) Velli, M., Grappin, R. and Mangeney, A., (1990) Comp. Phys. Communications 59, 153 “Solar Wind Expansion Effects on the Evolution of Hydromagnetic Turbulence in the Interplanetary Medium”

8) DeBruyne, P., Velli, M., and Hood, A.W., (1990) Comp. Phys. Communications 59, 55 “ The Ideal MHD Stability of Line-Tied Coronal Loops: a Truncated Fourier Series Approach”

9) Grappin, R.,Velli, M. and Mangeney, A., (1991) Annales Geophysicae 9, 416 “Alfv´enic Versus Standard Turbulence in the Solar Wind”

10) Velli, M., Grappin, R. and Mangeney, A., (1992) Geophys. Astrophys. Fluid Dyn., 62, 101 “Waves From the Sun?”

11) Velli, M., (1993) Astronomy & Astrophys., 270, 304 “On the Propagation of Ideal, Linear Alfv´en Waves in Radially Stratified Stellar Atmospheres and Winds”

12) Grappin, R., Velli, M. and Mangeney, A., (1993) Phys. Rev. Letts., 70, 2190, “Nonlinear Wave Evolution in the Expanding Solar Wind”

13) Velli, M. and Grappin, R. (1993) Adv. Space Res., 13, (9)49, “Properties of the Solar Wind”

14) Velli, M. (1994) Adv. Space Res., 14, (4)123, “Alfv´en Waves in the Solar Corona and Solar Wind”

15) Einaudi, G. and Velli, M. (1994) Space Science Revs., 68, 97, “Nanoflares and current sheet dissipation”

16) Velli, M. (1994) Astrophys. Journal Letts., 432, L55, “From supersonic winds to accretion: comments on the stability of stellar winds and related flows”

17) Velli, M, Habbal, S.R. and Esser R. (1994) Space Science Revs., 70, 391,“Coronal plumes and fine scale structure in high-speed solar wind streams”

18) Grappin, R. and Velli,M. (1996) Journ. Geophys. Res., 101, 425, “Waves and streams in the expanding solar wind”

19) Einaudi, G., Velli, M. Politano, H and Pouquet A. (1996) Astrophys. Journal Letts., 457, L113 “Energy release in a turbulent corona”

20) Velli, M. and Malara, F. (1996) Phys.ofPlasmas, 3, 4427, “Parametric instability of a large amplitude non-monochromatic Alfv´en wave”

21) Grappin, R., Cavillier, E. and Velli, M. (1997) Astron. & Astrophys., 322, 659, “Propagation of acoustic waves in isothermal winds in the vicinity of the sonic point”

22) Velli, M., Lionello, R. and Einaudi, G. (1997) Solar Phys., 172, 257, “Kink modes and current sheets in coronal loops”

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Plus a few other contributions in press.