SOCIEDAD ESPAÑOLA DE ASTRONOMÍA
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SEA

Libro de resúmenes
Abstract book

Física solar / Solar physics
Sesiones FS1 - FS2 / Sessions FS1 - FS2

Física solar / Solar physics (FS1)
Martes 17 de julio / Tuesday 17 July

15:30	**Elena Khomenko** Three-dimensional simulations of solar magneto-convection including effects of partial ionization (invitada/invited)
16:00	**Adur Pastor Yabar** Topología magnética del polo norte solar
16.15	**Ana Belén Griñón Marín** Evolución temporal de puentes de luz
16:30	**Andrés Adrover González** 3D numerical simulations of oscillations in prominences
16:45	**Andrés Asensio Ramos** Deep learning in Solar Physics
17:00	**Daniel Pacheco** A new analysis of near-relativistic electron events measured by the Helios mission
17:15	**PÓSTERES**

Three-dimensional simulations of solar magneto-convection including effects of partial ionization

Elena Khomenko (charla invitada/invited talk)

Over the last decades, realistic 3D radiative-MHD simulations have become the dominant theoretical tool for understanding the complex interactions between the plasma and the magnetic field on the Sun. Most of such simulations are based on approximations of magnetohydrodynamics, without directly considering the consequences of the very low degree of ionization of the solar plasma in the photosphere and bottom chromosphere. The presence of large amount of neutrals leads to a partial decoupling of the plasma and the magnetic field. As a consequence of that, a series of non-ideal effects (ambipolar diffusion, Hall effect and battery effect) arises. The ambipolar effect is the dominant one in the solar chromosphere. Here we report on the first three-dimensional realistic simulations of magneto-convection including ambipolar diffusion and battery effects. The simulations are done using Mancha3D code. Our results reveal that ambipolar diffusion causes measurable effects on the amplitudes of waves excited by convection in the simulations, on the absorption of Poynting flux and heating and on the formation of chromospheric structures. We provide a low bond on the chromospheric temperature increase due to the ambipolar effect using the simulations with battery-excited dynamo fields.

Topología magnética del polo norte solar

Adur Pastor Yabar, María Jesús Martínez González, Manuel Collados Vera

El magnetismo en las regiones polares del Sol, aún perteneciendo a lo que se conoce como magnetismo del Sol en calma (fuera de regiones activas), presenta ciertas características propias. Por un lado, la influencia de las regiones activas a estas latitudes es diferente a la del Sol en calma a latitudes bajas-intermedias. Por otro lado, este magnetismo muestra una clara modulación con el ciclo del campo magnético global solar. Así, el magnetismo en las regiones polares es fundamental en la comprensión del magnetismo solar.

Analizamos el magnetismo en una región cerca del polo norte solar. Para ello empleamos observaciones espectro-polarimétricas en dos líneas espectrales altamente sensibles al campo magnético que nos permiten inferir el vector campo magnético. El análisis incluye el estudio de dos regiones de Sol en calma adicionales. En primer lugar, en el centro del disco, donde la caracterización del campo magnético es óptimo. En segundo lugar, el Sol en calma del limbo ecuatorial nos permite estimar el efecto de observar cerca del limbo solar asumiendo que somos sensibles, estadísticamente, al mismo magnetismo que en el centro del disco.

Obtenemos que las características observadas en la región norte encajan bien con las obtenidas para el limbo ecuatorial. Así, el magnetismo de la región polar no muestra, topológicamente, diferencia con el observado para el Sol en calma en latitudes bajas. Además, obtenemos la primera evidencia de la presencia de lazos magnéticos de pequeña escala (<1000 km) como los que se habían detectado previamente en el centro del disco. Este descubrimiento es relevante ya que, si estas estructuras pueblan la superficie solar entera, podrían aportar la suficiente energía a capas altas de la atmósfera como para tener implicaciones en el calentamiento de la cromosfera y la corona solar. Estos resultados refuerzan el papel del magnetismo del Sol a pequeña escala en la energética global de la atmósfera solar, al ser este magnetismo independientemente del instante del ciclo solar.

Evolución temporal de puentes de luz

Ana Belén Griñón Marín, Adur Pastor Yabar, Rebecca Centeno Elliott, Héctor Socas Navarro

Los puentes de luz son estructuras alargadas que separan dos regiones umbrales de una mancha o poro. El brillo de estas estructuras es mayor que el de las umbras que los rodean, alcanzando casi el brillo del sol en calma. Estas estructuras suelen aparecer durante la formación o decaimiento de las manchas y poros. Dependiendo de sus propiedades físicas, los puentes de luz pueden mostrarse en formas filamentosas o granulares. Sus tiempos de vida son menores al de las manchas a las que pertenecen y tienden a ser muy dinámicos.

En este estudio hemos utilizado datos espectropolarimetricos observados con el espectrógrafo GRegor Infrared Spectrograph instalado en el telescopio GREGOR en el observatorio del Teide en Tenerife. Estas observaciones en el rango de 1.5 micras incluyen varias líneas fotosféricas con una gran sensibilidad magnética que nos permiten inferir las propiedades magnéticas y termodinámicas en capas profundas de la fotosfera. La mancha observada, corresponde a la mancha líder de la región activa NOAA 12049 que se observó desde el día 29 de abril al 5 de mayo del 2014 (15 barridos en total, tomados durante 4 días diferentes).

Una vez inferidos los diferentes parámetros físicos, estudiamos la estratificación y la evolución temporal de 3 puentes de luz que esta mancha desarrolla en el transcurso de su vida. Observamos que cada puente de luz se forma mediante 3 mecanismos diferentes. En un caso, el puente de luz aparece debido a la intrusión de un filamento penumbral en la umbra. Un segundo puente se forma por separación de una umbra en dos partes y observamos cómo sus propiedades físicas van cambiando conforme las dos regiones umbrales se van separando. Y, finalmente, el tercer puente se desarrolla por aproximación de dos umbras. Además, este puente muestra, al principio de su vida, dos partes bien diferencias tanto en sus propiedades físicas como morfológicas.

3D numerical simulations of oscillations in prominences

Andrés Adrover González, Jaume Terradas Calafell

Solar prominences (called filaments when they appear lying on the solar disc) are plasma structures located in the solar corona and are characterized by temperatures a hundred times lower and densities a hundred times greater than its surrounding. These cool and dense plasma structures are embedded in magnetic arcades standing above the photosphere.

Prominences are dynamic structures showing, among others, oscillatory motions. Since the first evidences of oscillations in prominences, several theoretical studies have analyzed the different modes of oscillation and their attenuation. The observational reports indicate that oscillations reveal a large range of periodicity, from 6 to 150 minutes, and a damping time values from 2 to 6 times their periods.

In order to advance in the study of large amplitude oscillations, 3D numerical simulations of solar prominences are required. In this work the ideal magnetohydrodynamic (MHD) equations are solved in three dimensions using a high order finite differences scheme. The prominence is represented by a dense plasma in a magnetic arcade permeated by a stratified atmosphere. The initial configuration is not in MHD equilibrium but it tends to relax around a stable state.

After the relaxation, we trigger the oscillations adding a velocity perturbation in the system that represents for example an EIT wave. Both longitudinal and transversal MHD oscillations are exited and the properties of these waves are analyzed in detail. In particular, the polarization of the motions, the periods and the damping times are characterized according to the global parameters of the prominence model.

Deep learning in Solar Physics

Andrés Asensio Ramos

In the last decade, machine learning has experienced an enormous advance, thanks to the possibility to train very deep and complex neural networks. In this contribution I show how we are leveraging deep learning to solve difficult problems in Solar Physics. I will focus on how differentiable programming (aka deep learning) is helping us to have access to velocity fields in the solar atmosphere, correct for the atmospheric degradation of spectropolarimetric data and carry out fast 3D inversions of the Stokes parameters.

A new analysis of near-relativistic electron events measured by the Helios mission

Daniel Pacheco, Neus Agueda, Angels Aran, Bernd Heber, David Lario

The interplanetary transport conditions of solar energetic particles (SEPs) have a direct influence on the characteristics of the observed temporal profiles and particle pitch-angle distributions. Making use of the Helios mission data we analyse with modern methods a sample of 17 near-relativistic electron events measured by either Helios 1 or Helios 2 at different heliocentric radial distances from the Sun.

The electron measurements provided by E6 instrument on board Helios spacecraft provide us with 8 sectors we can use to infer in a very good detail the characteristics and evolution of the electron pitch-angle distributions. The results of a Monte Carlo interplanetary transport model combined with an inversion procedure (SEPinversion) are used to fit the observed 300-800 keV electron directional intensities by taking into account, for the first time, the energetic and angular response of the detector. This method allows us to characterise the release time profile at the source and the transport conditions.

We present the electron mean free path and release time profiles inferred from the inversion of each event in our sample. For several of the events in our sample, we compare our results with previous studies. We highlight the importance of revisiting SEP events observed by Helios in order to better characterize the radiation environment that Solar Orbiter and the Parker Solar Probe will encounter.

Física solar / Solar physics (FS2)
Miércoles 18 de julio / Wednesday 18 July

9:00	**Jose Carlos del Toro Iniesta** On Fabry-Pérot etalon based instruments: The isotropic case
9:15	**David Orozco Suárez** On Fabry-Pérot etalon based instruments: The anisotropic case
9:30	**José Luis Ballester Mortes** The temporal behaviour of MHD waves in a partially ionized prominence-like plasma: Effect of heating and cooling with different radiative loss functions
9:45	**Juan Carlos Trelles Arjona** Looking for the best strategy to invert the Quiet Sun Stokes profiles
10:0	**Manuel Collados Vera** Desarrollo y primera luz de una unidad de campo integral para el telescopio GREGOR
10:15	**María Montes Solís** Inferencia de propiedades físicas de estructura fina de protuberancias
10:30	**Roberto Soler** Torsional Alfvén waves in the lower solar atmosphere: energy transport and dissipation
10:45	**Sergio Toledo Redondo** Solar wind - magnetosphere coupling via magnetic reconnection and the effects of ionospheric plasma

On Fabry-Pérot etalon based instruments: The isotropic case

José Carlos del Toro Iniesta, Francisco J. Bailén, David Orozco Suárez

Fabry-Pérot etalons are common devices in many astronomical instruments. They are typically used as filtergraphs, that is, as quasi-monochromatic imagers. Their basic theory is already known and appears in many elementary Optics textbooks. However, many of the assumptions underlying this theory are not valid in particular applications. Of special importance are cases when the optical configuration is not collimated or when the medium within the etalon is anisotropic (as for crystalline birefringent etalons) and, hence, polarization effects may show up. In this communication, we shall revisit the theory and study the etalons when they are not in collimated configuration as well. Suggestions on how to configure them within optical instruments will naturally appear.

On Fabry-Pérot etalon based instruments: The anisotropic case

David Orozco Suárez, Francisco J. Bailén Martínez, Jose Carlos del Toro

For many years, imaging spectropolarimetry of the Sun have been performed with Fabry-Pérot interferometers. Their basic theory is already known and appears in many elementary Optics textbooks. The medium within the etalon is often anisotropic (as for crystalline birefringent etalons) and, hence, polarization effects may show up. Such effects are usually not taken into account when designing the polarimeter. Etalons affect the modulation of the polarization state of the incoming light beam and hence the final polarimetric efficiencies. In this communication, we study the influence of the etalons in the polarimetric response of optical instruments, when the etalon is in telecentric and collimated configurations.

The temporal behaviour of MHD waves in a partially ionized prominence-like plasma: Effect of heating and cooling with different radiative loss functions

José Luis Ballester Mortes, M. Carbonell, R. Soler, J. Terradas

Small amplitude oscillations in prominences are known from long time ago, and from a theoretical point of view, these oscillations have been interpreted in terms of standing or propagating linear magnetohydrodynamic (MHD) waves. In general, these oscillations have been studied by producing small perturbations in a background equilibrium with stationary physical properties. Taking into account that prominences are highly dynamic plasma structures, the assumption of an stationary equilibrium is not realistic, and any imbalance between prominence heating and cooling processes produces a temporal variation of prominence temperature.

Prominence plasma is partially ionized, thus, when prominence plasma is heated the degree of ionization increases. On the contrary, when the prominence plasma cools down, recombination takes place decreasing the ionization degree. As a consequence, the temporal variation of the temperature and ionization degree modifies plasma parameters such as the mean atomic weight, resistivities, viscosity, thermal conduction coefficients, etc. During the heating process, the plasma goes from almost fully neutral to almost fully ionized, while during the cooling process, the plasma goes from almost fully ionized to almost neutral, therefore, the full expression for the specific internal energy able to describe the behaviour of the plasma in those different situations must be considered.

Our main aim here is to study how the temporal variation of temperature and plasma parameters modifies the temporal behaviour of MHD waves in a partially ionized prominence-like plasma. Furthermore, apart from considering a background whose temperature changes with time, perturbed optically thin radiation and thermal conduction as damping mechanisms for MHD waves are also considered, and we have sought for numerical solutions to the linear MHD wave equations. This approach is new since earlier studies of MHD waves in a partially ionized prominence plasma have always assumed an stationary background with constant temperature and ionization degree

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Looking for the best strategy to invert the Quiet Sun Stokes profiles

Juan Carlos Trelles Arjona, M. J. Martínez González,
B. Ruiz Cobo, A. Asensio Ramos

The strong magnetic activity at the solar surface manifests in form of sunspots and plages. Outside those active regions (ARs) the photosphere is characterized by the unperturbed granulation, i.e. the quiet Sun (QS). When observing the QS in polarized light, it is permeated by magnetic fields. The strongest fields (kG) are concentrated in vertical structures at the borders of the supergranular cells forming a network-like pattern, hence called the Network. Inside these cells, the solar surface is named the internetwork (IN). Those are the quietest areas in the photosphere and present the typical salt and pepper pattern in circular polarization characteristic of magnetic fields with mixed polarities at sub-granular scales. The analysis of these signals has revealed a weak, very small-scale, disorganized magnetism that covers the solar surface, from the equator to the poles (see e.g. the review by Sánchez Almeida & Martínez González 2011). Despite of the low magnetic energy as compared to ARs, the role of the QS in the general energy budget has been already proven (see e.g. Trujillo Bueno, Shchukina & Asensio Ramos 2004).

Though the importance of the QS for solar studies is clear, still at present, and after more than three decades of research, many questions are still unresolved.

In order to reach a higher knowledge about the QS we have inverted Stokes profiles (Fe I 630.2 nm lines) observed using the spectropolarimeter (Lites et al. 2001) aboard Hinode satellite (Kosugi et al. 2007). We first have increased the signal to noise ratio and the spatial resolution of the original data by applying the code by Asensio Ramos, A. (in prep.) for PCA denoising and deconvolution (using the point spread function of Hinode). To derive the magnetic field vector we have used the SIR (Stokes Inversion based on Response functions) code (Ruiz Cobo & del Toro Iniesta 1992) with two magnetic components. We have done inversions using different strategies (Milne-Eddington atmospheres, atmospheres with gradients in some of its physical quantities and so on) looking for the best one.

Desarrollo y primera luz de una unidad de campo integral para el telescopio GREGOR

Manuel Collados, T. Cedillo Vaz, C. Domínguez Tagle, M. Esteves Pérez, Nauzet Vega Reyes, E. Páez Mañá

Recientemente el IAC ha desarrollado una unidad de campo integral para el espectrógrafo GRIS del telescopio GREGOR. Con ella se puede obtener el espectro simultáneo de todos los puntos de un campo de visión de 6"x3", con una resolución angular del orden de 0.4 segundos de arco. La unidad es compatible con la espectropolarimetría, por lo que es adecuada para poder estudiar la evolución espacio-temporal de estructuras magnéticas solares, especialmente en la cromosfera, donde los fenómenos suelen ser muy dinámicos. En esta comunicación se describirá el diseño opto-mecánico (que incluye un sistema de barrido especialmente pensado para medir campos más grandes) y los resultados de la primera luz obtenidos en el telescopio. Asimismo se comentará los planes futuros para mejorar sus prestaciones.

Inferencia de propiedades físicas de estructura fina de protuberancias

María Montes Solís, Iñigo Arregui, Manuel Collados

Aún son muchas las preguntas sin resolver sobre la formación, estabilidad y dinámica de las protuberancias solares. En este trabajo, nos centramos en los hilos de la estructura fina que las forman y sus oscilaciones transversales. Por una parte, consideramos modelos teóricos de ondas magnetohidrodinámicas y observaciones para obtener información acerca de algunas características físicas, como la magnitud del campo magnético, la densidad del plasma o la longitud de los hilos. Por otra, consideramos modelos alternativos de amortiguamiento de ondas transversales observadas en este tipo de estructuras para calcular su plausibilidad relativa. En ambos tipos de análisis utilizamos técnicas de estadística Bayesiana. Los resultados muestran que los parámetros físicos de interés pueden inferirse. Además, el mecanismo conocido como absorción resonante en el continuo de Alfvén es el mecanismo de amortiguamiento más plausible, frente al mecanismo de absorción resonante en el contínuo lento y frente a la difusión de Cowling por ionización parcial del plasma.

Torsional Alfvén waves in the lower solar atmosphere: energy transport and dissipation

Roberto Soler, J. Terradas, R. Oliver, J. L. Ballester

It has been proposed that Alfvén waves play an important role in the energy transport through the solar atmosphere and may significantly contribute to the heating of the plasma. Here we theoretically investigate the propagation of torsional Alfvén waves in magnetic flux tubes expanding from the photosphere up to the low corona and explore the energy transport and dissipation. We use a realistic variation of the plasma properties and the magnetic field with height. Dissipation in the chromosphere is included by taking into account ion-neutral collisions and magnetic diffusion in a multifluid partially ionized plasma. Considering the stationary state, we assume that the waves are driven below the photosphere and propagate to the corona, while they are partially reflected and damped in the chromosphere and transition region. We study the dependence on the wave frequency of the energy reflectivity, transmissivity, and absorption, and determine the importance of wave dissipation for chromospheric heating.

Solar wind - magnetosphere coupling via magnetic reconnection and the effects of ionospheric plasma

Sergio Toledo Redondo, Mats Andre, Benoit Lavraud, Nicolas Aunai, Wenya Li, Jeremy Dargent, Barbara Giles, Stephen Fuselier, Roy Torbert, Christopher T. Russell

Magnetic reconnection is a key plasma process that couples the solar wind to the Earth's magnetosphere, permitting the exchange of energy and mass between these two plasmas, and converting large amounts of energy stored in the magnetic fields into kinetic energy of the particles. The magnetospheric side of the subsolar magnetopause is often populated by cold (10 eV) plasma of ionospheric origin, in addition to the common hot (10 keV) magnetospheric plasma. The presence of this cold plasma can mass-load the magnetospheric interface with the solar wind by 2-3 orders of magnitude, reducing the rate at which magnetic reconnection operates. In addition, the ion gyroradius of the cold plasma is much smaller than the hot ion gyroradius and introduces a new length-scale into reconnection and its associated processes. Finally, the cold plasma is heated inside the separatrix region of magnetic reconnection, although this mechanism is not always present.

We will first give an overview of magnetic reconnection between the Earth's magnetosphere and the solar wind, and then show MMS-NASA in-situ observations of magnetic reconnection with the presence of ionospheric cold plasma, compare them to kinetic Particle-In-Cell simulations and discuss the microphysical effects owing to the presence of the cold ionospheric plasma component.