CALLISTO: Exploring metre-wavelength emission from the active Sun.

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Introduction.

A plasma emits electromagnetic radiation, primarily by the excitation of free electrons in the Coulomb potential of the proton core or by free electrons undergoing transitions to other fine states or to bound states of atoms and ions, but also by bound electrons as they undergo transitions to other bound states. If the electrons in a plasma are implanted in a uniform background of interacting electric fields, the plasma will be in such a direction as to reduce the net effect of the plasma on the electric field back to its original state. Because of the inertia, the electrons will overshoot and oscillate around their equilibrium positions with characteristic frequency known as the plasma frequency.

The electric field is given by:

\[ E = \frac{N_e \chi}{m_e} \]  

where \( N_e \) is the charge density and \( \chi \) is the electric field.

We obtain an harmonic motion of vibration

\[ \frac{d^2x}{dt^2} + \omega^2 x = 0 \]

The frequency excited depends on the Particle density

\[ \omega_p = \frac{1}{\sqrt{\frac{N_e}{m_e}}} \]

where \( N_e \) is the electron charge, \( m_e \) is the electron mass.

Instrumentation.

In order to detect metre wavelengths, a Langenlard antenna was assembled. The antenna is a broadband, multi-element, vectorial, broadband antenna with an impervious and isolation characteristic that are regularly repetitive as a function of the excitation frequency.

The spectrometer have been shipped by an ETH engineer to the Trinity College Astrophysics Group. The instrument works with a PC software. The CALLISTO spectrometer is a composite of several standard electronic components readily available from the consumer market and assembled in a single RJ-45 (ethical) (1). After measuring the whole frequency range from 65 to 150 KHz in steps of 2.5 Hz it yielded up to 15,113 channels.

Fig. 1 Large period antenna assembled for the spectrophotograph.

Fig. 2 Callisto receiver assembled with ETV Zurich.

Fig. 3 Callisto operating with a PC.

Results.

Fig. 4 Plot of height and velocity of the shock, obtained by using methods of the Klassen models. Initial values for acceleration, height and velocity obtained.

Fig. 5 Scheme reference, the dipole of the active region is shown in a blue-red rectangle.

The orientation of the dipole vector, the new satellite cases (parallel and antiparallel).

Fig. 6 Alfven Mach number and velocity obtained. The function present a minimum compatible with the Klassen models.

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Fig. 8 Callisto velocity obtained from data compared with the models to discriminate the parallel or antiparallel case of the magnetic field.

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Fig. 10 Values for the magnetic field fitted with a power law function. The results are in agreement with the magnetic dipole of the Sun. Measurements of the magnetic field are difficult to obtain. With this method a compatible value is obtained using the spectrophotograph data.

Atmospheric ionization levels and transitions.

Using the spectrophotograph at TCD the plasma frequency transitions from day-night states and vice versa were measured. The spectrophotograph data was used to illustrate the ionization effects on the transition wavelengths. Investigating this emission a correlation with the solar activity was improved. The data related with the I and II class solar events are shown in the table below.

<table>
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<tr>
<th>Magnetic Field Obtained from KaK data</th>
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<td>Spectral transeion of Bn Castle. The peaks observed on 102 MHz due to commercial radio stations in the area. The spectrum is very typical. The Figure 12 Bn is the typical.</td>
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Data analysis.

The magneto-hydrodynamic (MHD) waves are of four kinds: two magnetic acoustic waves (slow and fast mode) which are compressible and can be subject to damping, and the so-called Alfven wave which propagates along the magnetic field and is incompressible. The Alfven wave propagates at the Alfven speed given by:

\[ v_A = \frac{B}{\sqrt{\mu_0 n_e m_e}} \]

where \( B \) is the magnetic field component normal to the shock front and \( n_e \) is the density of the plasma.

One model simplifies the plasma upstream of the downstream region (1) to shock front (upstream region) the plasma is characterized by the electron density \( n_e \) and the Larmor radius \( r_L \) in the magnetic field (2) (Down frequency branch). The plasma behind the shock is composed by the density \( n_e \) and, corresponding to the frequency \( \gamma \) (upper frequency branch (UFB)).

Defining two parameters, in this case, the density and the Larmor radius.

\[ \frac{B}{(2 \pi e)^{1/2}} \]

where \( \gamma \) is the ratio of the thermal pressure to magnetic pressure, an important parameter in plasma physics. Highly structured patterns observed in the UV image range indicate that coronal plasma is controlled by the magnetic field and \( \gamma \)."