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SOLAR RADIUS MEASUREMENTS WITH THE BDA

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ABSTRACT

Our goal is to study certain aspects of the decimetric emission produced in the solar corona. This study is basically composed of the quiet Sun emission. Therefore, we intend to use the data from the *Brazilian Decimetric Array* (BDA) at 1.2 and 1.7 GHz in order to determine the solar diameter at these frequencies and also to verify the existence, or not, of a brightening near the solar limb and characterize it. Both types of data will be used to test and improve the solar atmospheric model developed by Selhorst and collaborators.

INTRODUCTION

Solar Radius

Due to its importance in the structure determination of solar atmospheric models, the solar radius has been measured in several wavelengths from radio through the visible part of the electromagnetic spectra. During the last two decades, the optical observations failed in showing an 11 year periodic variation in the solar radius. The measured variation ranged from tens to miliarcsecond to 0.5 arcsec, both in phase and anticorrelated with the solar activity cycle.

Detection of the solar radius changes at radio frequencies indicate that the location in the atmosphere where the radio emission is produced is varying. Actually, these variations reflect changes in the local distribution of temperature and density of the solar atmosphere. Previous research (Bachurin, 1983) has shown an increase in the solar radius of 9.6 and 13.8 arcsec at 13 and 8 GHz, respectively, from 1976 to 1981. More recently, Costa et al. (1999) measured the solar radius at 48 GHz and found that it decreased in correlation with activity cycle between 1991 e 1993. An important aspect is that the radius measurements are very well correlated with the changes observed in the solar irradiance, which may produce climate variations at Earth.

In 2004, Selhorst et al. (2004) showed that the variation of the solar radius at 17 GHz depends of where and when it is measures. The average radius changes by 4 arcsec between solar minimum and the maximum, following very well the solar activity cycle. On the other hand, if the radius is measured only in the Polar Regions, the variations are smaller, only about 1 arcsec and are anticorrelated with the solar cycle. Their conclusion is that the solar radius is strongly influenced by the presence of active regions near the limb, which obviously follow the solar cycle, whereas the polar radius has a strong contribution from the polar brightening that varies inversely with the 11 year cycle. Moreover, a strong limb brightening of 10 to 15 % is observed at 17 GHz, being more intense (25-30%) in the Polar Regions. The average thickness of the limb brightening is of the order of 60 arcsec (Selhorst et al., 2003).

Solar Limb Brightening

The study of the temperature distribution with position on the solar disk, obtained from radio observations, have fundamental implication on the determination of the structures of the chromosphere and corona. These variations are observed as a brightening near the solar limb and either be caused by the positive temperature gradient in the chromosphere or by the presence of jets of matter called spicules. An important phenomenon observed in the 17 GHz solar maps is this brightening near the limb, which is seen all around the Sun forming a ring of non uniform distribution.

Despite the report of several authors (Shimabukuro et al., 1975; Lindsey and Hudson, 1976; Horne et al., 1981; Lindsey et al., 1981; Gomez-Gonzalez et al., 1983; Lindsey et al., 1984; Bastian et al., 1993) of limb brightening detection at several wavelengths from 33 to 1000 GHz, no systematic study has been performed searching for a variation with the solar cycle. Very little information exists about angular variations of this ring. On a previous work at 350 GHz (Bastian et al., 1993), a limb brightening of approximately 16 % above quiet Sun levels was found, appearing differently in the North-South direction from the East-West one. Efanov et al. (1980) identified that the polar limb brightening was anticorrelated with the solar activity cycle.

It is believed that the limb brightening is due to two factors: i) increase of the chromospheric temperature with height (opposite to the limb darkening observed at optical wavelengths) and ii) presence of spicules which appear more prominently at the solar limb.

Spicules are fundamental components of the solar chromosphere. At the limb they are seen as jets of matter and can be observed in chromospheric spectral lines, such as H-alpha. The spicules have a rising mass flux, approximately 100 times larger than that of the solar wind. These structures are a challenge to the theories which need to explain how the chromospheric material is dragged to such great heights without increasing the temperature by about 10000 K, the temperature of the chromosphere.

OBSERVATION

To determine the solar radius and study the limb brightening at 1.2 and 1.7 GHz we plan to use the data from the *Brazilian Decimetric Array* (BDA). It will be interesting to compare these results with simultaneous observations from the Rádio Observatório de Itapetinga (ROI), at 22 and 43 GHz.

METHODOLOGY

The solar limb is defined as the point where the quiet Sun intensity falls to half its most common value (the quiet Sun level). The set of points of all the limb positions form a circumference which will be fit by the least square method in order to obtain the solar radius. This measurement will determine the region in the solar atmosphere where the decimetric emission is being produced, and it will be possible to compare this result with the data obtained at other wavelengths (Costa, Homor and Kaufmann, 1986).

As for the solar limb brightening, its presence near the limb will be studies from the convolution of a flat disk, representing the Sun, with the real antenna beam (Costa et al., 2002). This model will then be subtracted from the observations, which result will then show, or not, the existence of the brightening. Once identified, it will possible to obtain its intensity, width, and angular distribution, possibly understanding its main causes. We will also analyze its temporal correlation with the solar activity cycle.

SOLAR ATMOSPHERE MODEL

We intend to test the quiet Sun characteristics at 1.2 and 1.7 GHz, such as radius and limb brightening, and compare these with the values derived from solar models. As a model of the solar atmosphere, we will use the bidimensional atmosphere developed to describe the quiet Sun atmosphere based on previous models and confronted with observational data at 17 GHz 17 GHz (Selhorst et al., 2005). Several authors (Vernazza et al., 1981; Fontenla et al., 1993) have developed models for the solar atmosphere, however these models were based on spectral line data from the photosphere and lower chromosphere, and these models do not agree with observation made at radio frequencies.

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