Chapter 13
The Radio Sun and Planets

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ABSTRACT

The radio emissions from the Sun and planets provides a new window to explore and improve our understanding of these celestial objects and its magnetic activities. Radio emissions allow us to see things that are not seen in other wavelengths. The radio emissions observed from the Sun and planets can generally be divided into thermal and non-thermal. The thermal emission is related to the temperature of the objects, i.e. the blackbody radiation and the non-thermal emission is usually associated with the magnetic fields.

THE RADIO SUN

Our Sun is one of the earliest celestial objects studied by radio astronomers. The radio emissions from the Sun provides a new window to explore and improve our understanding of the solar atmosphere and its magnetic activities. Solar radio astronomy has become an emerging field that combines solar physics and radio astronomy, where large amount of observations data of the radio Sun coupled with plasma physics has been used to understand the complex and dynamics processes of the origin of solar radio emissions.

Short History

The detection of radio waves from extraterrestrial sources such as our Sun were unsuccessful in the earlier years. This was due to the primitive technology of the radio telescope during its early stage of development and also of the absence of knowledge of the existence of a screening ionosphere. Another hold back that the Sun's radio emission was not detected almost a decade after celestial radio waves were detected was due to the missing knowledge that solar activity affects the radio emission of the Sun, and some experiments unfortunately were carried out during the periods of low solar activity.

So it was not until 1942 that the first detection of the solar radio burst was made, by accident. During World War II, on February 26 to 28, 1942, the British army received strong interference that initially was suspected to be jamming signals transmitted by the Germans. But soon it turned out that it was caused

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by the Sun. James Stanley Hey noted that the radiations were between dawn and sunset, and were not observed at night. He concluded that the disturbance was of solar origin by going through the bearings and elevations of the receiving sets and found that the bearings moved throughout the day and was always within a few degrees of that of the Sun. It is also noted by Hey that the radiation appears to have been associated with the occurrence of a big sunspot group on the Sun at that time.

Earlier in 1940, Grote Reber observing the Sun at a wavelength of 187 cm reported negative results. Again, in a paper published in 1942, he characterized his results as inconclusive. However, in 1944, he finally reported the detection of solar radiation with his new and improved apparatus. Reber suggested that this long-wave radiation could be set up in the corona of the Sun. In 1945, George Clark Southworth published his results on the observation of microwave radiation coming from the Sun during the summer months of 1942 and 1943. The observation was carried out at three widely spaced wavelength in the region between 1 and 10 cm.

In the years following World War II, the development of radar antenna and receiver technology due to the war has helped to flourish the field of solar radio astronomy. The need for continuous and systematic observations of the Sun was recognized due to the great variability of the Sun's radio emission. The two leading countries that have made significant contributions to the field then were England and Australia, where the basic techniques of observations, such as spectrographic measurement, flux measurement and polarization measurement were developed.

Radio Emission from The Sun

The radiation emitted by our Sun is not only limited to visible light. In fact, it emits radiation over a very wide frequency range in the electromagnetic spectrum from ultraviolet to infrared and to radio waves. It is one of the strongest radio sources in the sky. The Sun emits radio waves through two mechanisms: thermal and non-thermal. The emission through thermal mechanism is due to its high temperature and at higher frequencies. The outermost solar atmosphere, i.e. the corona, is too tenuous to be detected by other ground-based observations except for its radio emissions. These emissions are caused by the gyrations and collisions of thermal electrons in the magnetic field that are able to produce sufficient power to be detected on the ground. The non-thermal mechanism emits at lower frequencies and is due to synchrotron radiation when electrons spiral around magnetic field lines. The violent and dynamic events happened in the solar atmosphere (such as flare and corona mass ejection) are characterized by their non-thermal radio emissions.

The radio emission from the Sun is rather complicated. From analyzing the solar radio flux density as a function of wavelength (Figure 1), it can be seen that for wavelength greater than 1 cm (frequency less than 30 GHz), the solar radio emission is divided into two parts, identified as the "quiet Sun" (constant component) and the "active (or disturbed) Sun" (variable component). The quiet Sun is the background solar radio emission due to heat at the time of minimum sunspot activity and is relatively stable. Thus, it is often used for calibration. The active Sun (radio burst) is due to strong magnetic activity such as flare and sunspots, which can exceed the quiet Sun emission by several orders of magnitude. There is a third component known as the slowly varying component, the slow day-to-day variation in radio emission, which is associated mainly with active regions, visible or invisible, on the Sun's disk.

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