**LECTURE-10: THEORY OF THE ORIGIN OF SPOTS.**

**The theory of the origin of spots**

Early theories of the origin of sunspots were based on the adiabatic cooling of gas observed in the light equilibrium region. One of these theories was proposed by Ressel in 1921 and another by Rosseland and Berknis in 1926. However, the discovery of a hydrogen convective zone in the surface layer of the Sun has created difficulties for the theory of adiabatic cooling.

A hypothesis explaining the cooling of sunspots by the influence of the magnetic field was proposed by Birman in 1941 and later by Hale. According to Birman's theory, there is magnetic field convection in spots, which slows down the flow of energy directed towards the spot, and as a result, this process causes a decrease in temperature in the spot area. This, in turn, causes the spot to appear black against the background of the photosphere. However, in later years, the observation of granule cells in the shadow part of the spots undermined the reputation of this theory. It should be said that the granulation cells in the observed core, when compared with the photosphere granules, it turned out that the magnetic field has a direct effect on the convective flow. As a result, convection, although not completely suppressed in the spot,

According to Hale's theory, heat energy rising to the surface of the Sun due to convection, as a result of its distribution over a large surface area, cools and forms a black spot. According to this hypothesis, the convection current rises only along the magnetic field lines, and in spots, according to the classical idea of ​​the magnetic field, its lines of force spread along the surface of the sun.

Although Bierman and Hale's hypothesis cannot be fully justified by the results of modern observations, there is sufficient evidence today that the cooling of the plasma in the spots is due to the partial inhibition by the magnetic field of the convection that transports the energy to the surface of the Sun.

**The spectrum of sunspots**

The spectrum of sunspots is the same as the spectrum of the photosphere, i.e. the absorption spectrum, in which the spectral lines with a small awakening potential increase compared to those of the photosphere, while the intensity of those with a large awakening potential, on the contrary, decreases. . In order to determine the physical parameters (speed of motion, magnetic field strength, etc.) related to the spot in the sunspot spectrum, when taking the spot spectrum, the height of the spectrograph slit is selected so that the spectrum includes the photosphere on both sides of the spot.

Spectral lines in the spectrum of a spot, in contrast to those of a quiescent photosphere, are shifted to the red or violet side of the spectrum, mainly in the penumbra of the spot, indicating the presence of motion. The shift of a given wavelength λ is ±Δis λ, then the speed of light (the line-of-sight component of the speed) according to the Doppler effect

found in formulas. Here, c represents the speed of light, and the positive sign of the speed indicates that the plasma mass consisting of atoms that gives the spectral line moves away from the observer with a speed, and the minus sign indicates that it approaches with such a speed.

1. Also, when irradiating plasma atoms are in the magnetic field of the spot, spectral lines are split into pieces (especially in the part of the spot related to the nucleus). This phenomenon is called the Zeeman effect. According to the Zeeman effect, the spectral line is divided into two or three components, depending on the location of the magnetic field strength vector in the observed spot area relative to the line of sight direction. If the field strength vector (H) is in the same direction as the line of sight, then the spectral line splits into two components (+s,-s), which are rotationally polarized. If H is the direction of the vector, 90 with the direction of the line of sight°forms an angle with , then the spectral line is divided into 3 components (+s,π, -s) are divided and they are linearly polarized. In the first case, the intensity of the components is proportional to each other I-s=I+s, and in the second case I-s=I+s=Iπ/2 is in the form of a ratio.