The Sun
Introduction, the structure of the sun, sun spots, the earth's orbit around the sun, the seasons.

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Lecture one

1-introduction

The sun is a sphere of intensely hot gaseous matter with a diameter of 1.39×10^9 m and on the average distance, 1.5×10^{11} m from the earth. As seen from the earth, the sun rotates on its axis about once every 4 weeks. However, it does not rotate as a solid body; the equator takes about 27 days and the Polar Regions take about 30 days for each rotation. The sun has an effective blackbody temperature of 5777 K. The temperature in the central interior regions is variously estimated at 8×10^6 to 40×10^6 K and the density is estimated to be about 100 times that of water.

The sun is, a continuous fusion reactor. Several fusion reactions have been suggested to supply the energy radiated by the sun. The most important is a process in which hydrogen (i.e., four protons) combines to form helium (i.e., one helium nucleus); the mass of the helium nucleus is less than that of the four protons, mass having been lost in the reaction and converted to energy.

2. Sun structure:

A schematic structure of the sun is shown in Figure 1. It is estimated that 90% of the energy is generated in the region of 0 to 0.23*R* (where *R* is the radius of the sun), which contains 40% of the mass of the sun. At a distance 0.7*R* from the center, the temperature has dropped to about 130,000 K and the density has dropped to 70 kg/m^3; here convection processes begin to become important, and the zone from 0.7 to 1.0 *R* is known as the **convective zone**. Within this zone the temperature drops to about 5000 K and the density to about 10−5 kg/m^3.
The sun's surface appears to be composed of granules (irregular convection cells), with dimensions from 1000 to 3000 km and with cell lifetime of a few minutes. Other features of the solar surface are small dark areas called pores, which are of the same order of magnitude as the convective cells, and larger dark areas called sunspots, which vary in size. The outer layer of the convective zone is called the **photosphere**. The edge of the photosphere is sharply defined, even though it is of low density (about 10−4 that of air at sea level). It is essentially opaque, as the gases of which it is composed are strongly ionized and able to absorb and emit a continuous spectrum of radiation.

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Outside the photosphere is a more or less transparent solar atmosphere, observable During total solar eclipse or by instruments that occult the solar disk. Above the photosphere is a layer of cooler gases several hundred kilometers deep called the reversing layer. Outside of that is a layer referred to as the chromosphere, with a depth of about 10,000 km. This is a gaseous layer with temperatures somewhat higher than that of the photosphere but with lower density. Still further out is the corona, a region of very low density and of very high 10^6 K temperature.

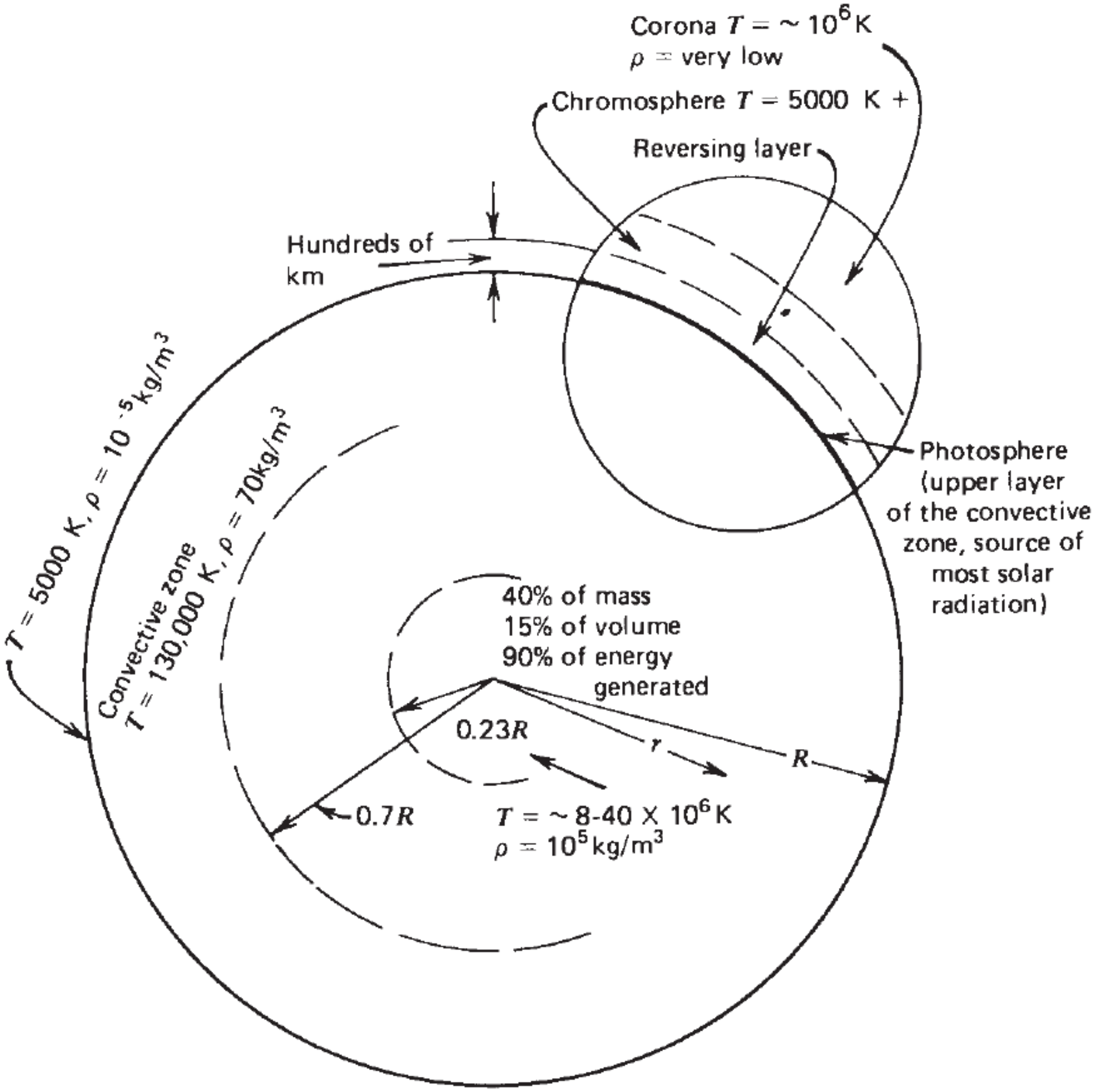

Figure 1: sun structure

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3- Solar Surface Activity: Sunspots

Sunspots are relatively dark regions on the photosphere-the surface of the sun. The sunspots have an average size of about 10,000 km. Sunspots are cooler regions having an average temperature of about 40000K, compared to an average temperature of 60000K for the photosphere. Owing to the relatively low temperature, sunspots appear black. Figure 2 illustrates a large sunspot group photographed with the 100-inch telescope on Mount Wilson. The average length of time between sunspots maxima is about 11 years; the so-called *11-year cycle.* It is believed that sunspots are associated with the very strong magnetic fields that exist in their interiors. Magnetic field measurements utilizing the Zeeman Effect (the splitting of a spectral line into several separate lines ,Show that pairs of sunspots often have opposite magnetic polarities. For a given sunspot cycle, the polarity of the leader spot is always the same for a given hemisphere. With each new sunspot cycle, the polarities reverse. The cycle of the sunspot maximum having the same polarity is referred to as the *22-year cycle.* The sunspot activities have been found to have a profound influence on many geophysical phenomena and on atmospheric processes.

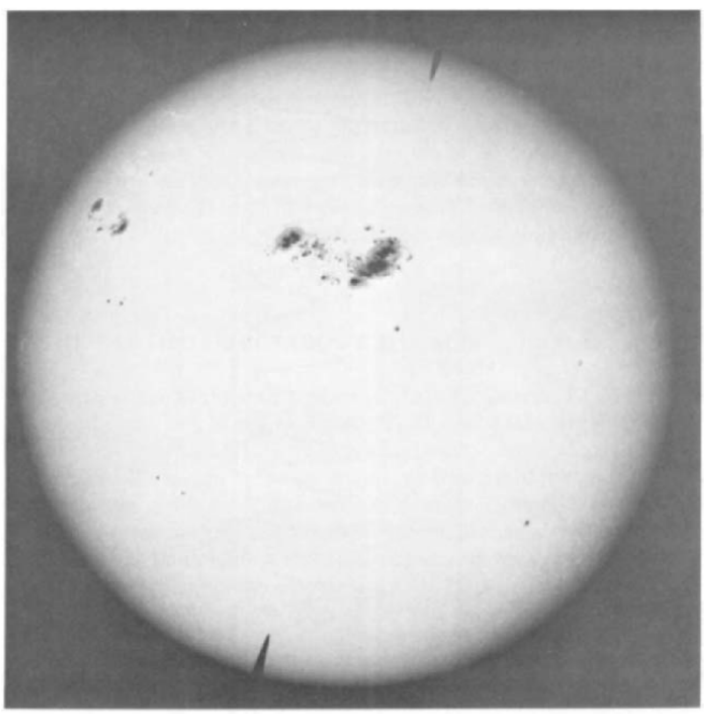

Fig.2 A large cluster of sunspots photographed with the 100-inch telescope in 1947 at sunspot maximum. The lower photograph is an enlarged view.

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4- The earth's orbit about the sun

Meanwhile, the earth with a mass of 6 x 10^{27} g, moves eastward around the sun once in approximately 365 days. The earth's orbit about the sun and the earth's rotation about its axis are the most important factors determining the amount of solar radiant energy reaching the earth, and the climate and climatic changes of the earth-atmosphere system. Owing to the rotation of the earth about its axis, the earth assumes the shape of an **oblate** spheroid, having equatorial and polar radii of 6378.17 and 6356.79 km, respectively. Its orbit around the sun is an **ellipse**, and the axis of its rotation is tilted as shown in Fig. 3.

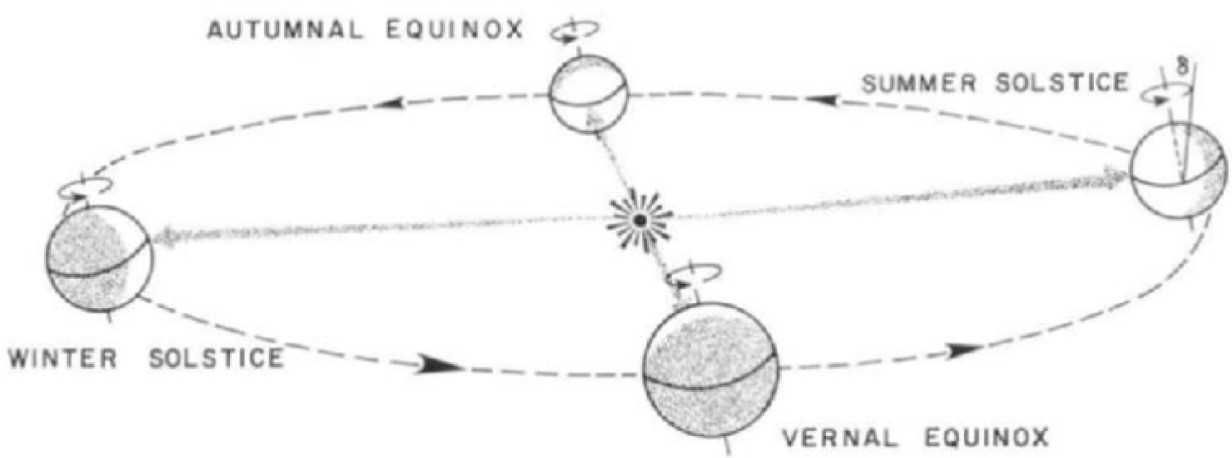

Fig. 3: The earth's orbit about the sun and effects of the obliquity of the ecliptic on the seasons.

There are three ways in which the earth's orbit about the sun varies .The earth orbital eccentricity, defined as the ratio of the distance between the two foci to the major axis of the ellipse, fluctuates within about 0.05 with a variable period of about 100,000 years. The mean eccentricity of the earth's orbit is about 0.017. In reference to Fig. 2, the axis of the earth's rotation is tilted at an angle of 23.5° from the normal to the plane of the ecliptic, the inclination angle. This angle, representing the obliquity of the ecliptic, varies cyclically over an average range of 1.50 with a period of about 41,000 years. In addition to these two factors, there is a very slow westward motion of the equinoctial points along the ecliptic, called *precession*, caused by the attraction of other planets upon the earth.

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