CHAPTER V.

PHYSICAL PROPERTIES OF THE SUN.

When viewed through powerful telescopes, provided with coloured glasses to take off the glare which would otherwise injure our eyes, the Sun is observed to have frequently large and perfectly black spots upon it—surrounded with a kind of border less completely dark, called a penumbra. When watched from day to day, or even from hour to hour, they appear to enlarge or contract, to change their forms, and at length to disappear altogether, or to break out anew in parts of the surface where none were ever before. In such cases of disappearance, the central dark spot always contracts into a point, and vanishes before the border. Occasionally they break up, or divide into two or more, and in those offer every evidence of that extreme nobility which belongs only to the fluid state, and of that excessively violent agitation which seems only compatible with the atmosphere or gaseous state of matter. The scale on which their movements takes place is immense. A single second of angular measure as seen from the earth, corresponds on the Sun's disc to 465 miles; and a circle of this diameter—containing therefore nearly 220,000 square miles—is the least space which can be distinctly discerned on the Sun as a *visible area*. Spots have been observed, however, whose linear diameter has been upwards of 45,000 miles; and even if some records are to be trusted, of much greater extent.

Many other circumstances tend to corroborate this view of the subject. The part of the Sun's disc not occupied by spots is far from uniformly bright. Its ground is finely mottled with an appearance of minute dark dots or pores, which when attentively watched, are found to be in a constant state of change.

Lastly in the neighbourhood of great spots, or extensive groups of them, large spaces of the surface are often observed to be covered with strongly marked, curved, or branching streaks, more luminous than the rest, called *faculæ*, and among these, if not already existing, spots frequently break out. They may, perhaps be regarded with most probability as the ridges of immense waves in the luminous regions of the Sun's atmosphere, indicative of violent agitation in their neighbourhood.

But what are the spots? Many fanciful notions have been broached on this subject, but only one seems to have any degrees of physical probability; viz. that they are the dark, or at least comparatively dark, solid body of the Sun itself, laid bare to our view by those immense fluctuations in the luminous regions of its atmosphere, to which it appears to be subject. Respecting the manner in which this disclosure takes place, different ideas again have been advocated. Lalande suggests, that eminences in the nature of mountains are actually laid bare, and project above the luminous ocean, appearing black above it. while their shoaling declivities produce the penumbrae, where the luminous fluid is less deep. A fatal objection to this theory is the perfectly uniform shade of the penumbra and its sharp termination, both inwards, and where it borders on the bright surface. A more probable view has been given by Sir William Herschel, who considers the luminous strata of the atmosphere to be sustained far above the level of the solid body by a transparent elastic medium, carrying on its upper surface, or rather, to avoid the former objection, at some considerably lower level within its depth, a cloudy stratum which, being strongly illuminated from above, reflects a considerable portion of the light to our eyes, and forms a penumbra, while the solid body, shaded by the clouds, reflects none. The temporary removal of both the strata, but more of the upper than the lower, he supposes effected by powerful upward currents of the asmosphere, arising perhaps from spiracles on the body, or from local agitations.

That the temperature at the visible surface of the Sun cannot be otherwise than very elevated, much more so than any artificial heat produced in our furnaces, or by chemical or galvanic processes, we have indications of several distinct kinds—1st, from the law of decrease as the squares of the distances, it follows, that the heat received on a given area exposed at the distance of the earth, and on an equal area at the visible surface of the Sun, must be in the proportion of the area of the sky occupied by the Sun's apparent disc to the whole hemisphere, or as 1 to 300,000. 2dly, from the facility with which the calorific rays of the Sun traverse glass, a property which is found to belong to the heat of artificial fires in the direct proportion of their intensity. 3dly, from the fact that the most vivid flames disappear, and the most intensely ignited solids appear only as black spots on the disk of the Sun when held between it and the eye. From this last remark it follows that the body of the Sun however dark it may appear when seen through its spots may nevertheless be in a state of most intense ignition. It does not however follow of necessity that it must be so. The contrary is at least physically possible. A perfectly reflective canopy would effectually defend it from the radiation of the luminous regions above its atmosphere, and no heat would be conducted downwards through a gaseous medium increasing rapidly in density. That the penumbral clouds are highly reflective, the fact of their visibility in such a situation can leave no doubt. This immense escape of heat by radiation, we may also remark, will fully explain the constant state of tumultuous agitation in which the fluids composing the visible surface are maintained and the continued generation and filling in of the pores without having recourse to internal causes.

The Sun's rays are the ultimate source of almost every motion which takes place on the surface of the globe. By its heat are produced all winds, and those disturbances in the electric equilibrium of the atmosphere which give rise to the phenomena of terrestrial magnetism. By their vivifying action, vegetables are elaborated from inorganic matter, and become in their turn the support of animals and of man, and the sources of those great deposits of dynamical efficiency which are laid up for human use in our coal strata.—By them the waters of the sea are made to circulate in vapour through the air, and irrigate the land, producing