from a low level, and sometimes reach considerable elevations in the form of eruptive prominences.

In such an exploration of the sun’s atmosphere it might be anticipated that definite currents, or some evidences of atmo­spheric circulation analogous to those familiar in terrestrial meteorology, would be discovered. Neither the forms nor the motions of the calcium flocculi revealed the existence of such currents, but in the higher region shown by the hydrogen photographs the distribution of the dark flocculi suggested the operation of definite forces, though their nature remained obscure until the spring of 1908. At that time monochromatic photographs of the sun were first made on Mount Wilson with the red (Hα) line of hydrogen, previous hydrogen photographs having been taken with Hβ, Hγ or Hδ in the blue or violet. On account of the relatively great strength of Hα at a consider­able distance from the photosphere, the new photographs recorded flocculi at high levels previously unexplored. The forms of these flocculi show that all sun-spots are vortical in nature, and are probably analogous to terrestrial cyclones or tornadoes. Most of the solar vortices indicate clockwise rotation in the southern hemisphere and counter-clockwise rotation in the northern, as in the case of terrestrial cyclones. But frequent exceptions have been observed in which the direction of rotation is reversed. The study of these vortices has led to the discovery of a magnetic field in sun-spots, apparently caused by electric convection in the vortices.

It is evident that by the use of a spectroheliograph of suffi­ciently high dispersion, photographs may be taken of vapours in the sun represented by lines narrower than those of calcium and hydrogen. Such work has been in progress both at Mount Wilson and at Meudon, and the erection of a spectroheliograph of 75 ft. focal length on Mount Wilson was at the end of 1908 contemplated for an early date.

Descriptions of spectroheliographs by Hale, Deslandres, Newall and others, may be found in various papers in *Astronomy and Astrophysics, Astrophysical Journal, Comptes rendus, Bulletin astronomique,* and other periodicals. (G. E. H.)

**SPECTROSCOPY** (from Lat. *spectrum,* an appearance, and Gr. *σκοπeiv,* to see), that branch of physical science which has for its province the investigation of spectra, which may, for our present purpose, be regarded as the product of the resolution of composite luminous radiations into more homogeneous components. The instruments which effect such a resolution are called spectroscopes.

1. *Introductory.—*The announcement of the first discoveries made through the application of spectroscopy, then called spectrum analysis, appealed to the imagination of the scientific world because it revealed a method of investigating the chemical nature of substances independently of their distances: a new science was thus created, inasmuch as chemical analysis could be applied to the sun and other stellar bodies. But the beautiful simplicity of the first experiments, pointing apparently to the conclusion that each element had its characteristic and invariable spectrum whether in the free state or when combined with other bodies, was soon found to be affected by complications which all the subsequent years of study have not completely resolved. Compound bodies, we now know, have their own spectra, and only when dissociation occurs can the compound show the rays characteristic of the element: this perhaps was to be expected, but it came as a surprise and was not readily believed, that elements, as a rule, possess more than one spectrum according to the physical conditions under which they become luminous. Spectrum analysis thus passed quickly out of the stage in which its main purpose was “ analysis ” and became our most delicate and powerful method of investigating molecular properties; the old name being no longer appropriate, we now speak of the science of “Spectroscopy.”1 Within the limit of this article it is not possible to give a complete account of this most intricate branch of physics; the writer therefore confines himself to a summary of the problems which now engage scientific attention, referring the reader for details to H. Kayser’s excellent and complete *Handbuch der Spectroscopic.*

2. *Instrumental.—*The spectroscope is an instrument which allows us to examine the vibrations sent out by a radiating source: it separates the component parts if they are homo- geneous, *i.e.* of definite periodicity, and then also gives us the distribution of intensity along the homogeneous constituents. This resolution into simple periodic waves is arbitrary in the same sense as is the decomposition of forces along assumed

1 The present writer believes that he was the first to introduce the word “ Spectroscopy ” in a lecture delivered at the Royal Institution in 1882 *(Proceedings,* vol. ix.).