W. H. JULIUS, 1860–1925

By A. EINSTEIN

With the passing away of W. H. Julius, one of the most original exponents of solar physics has left us. These few lines will be devoted to the work of this old friend of mine. They are written with the hope that his views on taking refraction into account in explaining solar phenomena may not be temporarily forgotten by oversight.

Julius began with his studies in mathematics and physics at the University of Utrecht in 1879. He directed his interest to experimental physics, working chiefly on emission and absorption in gases, until the age of thirty-one. Then, in 1891, a work of A. Schmidt, *Die Strahlenbrechung auf der Sonne, ein geometrischer Beitrag zur Sonnenphysik*, turned his attention to the field of solar physics, to which he thereafter devoted his entire life.

Julius did not advocate Schmidt's conception that the sharp edge of the sun was a phenomenon caused by refraction due to a radial density-gradient; for he recognized that scattering and absorption in the outer strata of the sun would necessarily prevent the formation of rays as long as those required by the Schmidt theory. He became convinced, however, that deviations from rectilinear propagation of light explained solar phenomena which would be difficult to comprehend if we ascribed to emission, absorption, and motion only, the distribution of light we see on the sun, and the velocity with which this distribution changes.

To do justice to the viewpoint of W. H. Julius, we must next ask what velocities are attained by matter in the outer strata of the sun. Observation gives no direct answer to this question. A priori, it is doubtful that motion of material is responsible for every shift of center of intensity of a spectral line, and for every motion of a singularity of intensity on the sun's disk. According to Julius, the only phenomena that give a direct measure of velocities of matter at the surface of the sun are sun-spots. That they are vortices is shown by the Zeeman effect found by Hale. Since familiar theorems of hydrodynamics show that the material of a vortex moves along with it, we may take the relative velocity of the spots as a velocity of matter. The velocities thus obtained average 0.15 km/sec., and never exceed 0.4 km/sec. Therefore Julius concluded, and in my opinion correctly, that we may not postulate essentially higher velocities in explaining solar phenomena.

Thus, for example, if the nuclei of granulations move with velocities of 3 to 4 km/sec. we may not think of the granulations as matter moving at such speeds. Julius viewed them as products of local variations of density of the solar atmosphere, accompanied by variable bending of rays from the photosphere. The velocities mentioned would thus be those of compressional waves, which actually are of that order of magnitude.

The distribution of intensity in sun-spots Julius likewise sought to trace back in an analogous way, at least in part, to refraction of light from the photosphere. To support such a view, he used among others an observation of Maunder, that far more spots, in the mean, appear on the eastern half of the sun's disk than on the western half. Julius explained this paradoxical finding by the slant produced in a vortex by inequalities (relative to latitude and depth) in the rotation of the sun. The upper portion comes to precede the rest of the vortex, thus inclining its axis at various angles to the line of sight, refraction being most manifest when this angle is small.

Prominences and the chromosphere Julius also sought to ascribe to variations of density (gradients) occurring in the outer part of the solar atmosphere. The transient motion observed in prominences, with velocities of image as high as a few hundred kilometers per second, he ascribed to minor displacements of density-gradients. He thought of the light as originating in the chromosphere, and being influenced by strong refraction in the close vicinity of an absorption line.

Julius' conception of the origin of Fraunhofer lines seems to me to be of particular importance. The observed lines are much broader than mere absorption lines corrected for Doppler effect. The broadening is explained by molecular scattering, and (chiefly) by anomalous refraction in irregular strata of gas. Because of the high refractive power near the absorption line of a substance, anomalous refraction must limit emission just as molecular scattering does.

But in contrast with the latter, the former causes an asymmetrical broadening of the lines. Julius thus explained shifts which, ascribed to a Doppler effect, called for improbably large velocities varying from line to line. In the same way he explained why the shift toward the red observed in the center of the sun differs from that at the periphery. He believed that the entire observed displacement of lines toward the red had to be explained in this way, and, therefore, held the opinion that the shift required by the theory of relativity does not exist.

I am not competent to render judgment on the reach of Julius' ideas, but I believe that they deserve careful consideration, particularly in the discussion of shifts in spectral lines. These few remarks will have served their purpose if they bring anew to the attention of the profession the work of this clear-sighted, artistically fine-spirited man.

NATUURKUNDIG LABORATORIUM DER RIJKS-UNIVERSITEIT
LEIDEN
December 14, 1925