SOLAR CORONA*

THE solar corona is a spectacular feature of the Sun's outer envelope which manifests itself at total solar eclipse as a pearly white halo round the black disc of the moon. The recognition that the corona is a region of high temperature of the order of millions of degrees has enthused added interest during the past two decades in coronal research.

The 'atmosphere' of the sun, observationally as also theoretically, can be divided into three superincumbent layers, namely, the photosphere, the reversing layers, and the chromososphere in order of increasing level. The boundaries between these layers are only roughly defined, but broadly speaking the photosphere gives rise to the continuous spectrum, the reversing layers to the absorption or Fraunhofer spectrum, and the chromosphere to the bright line flash spectrum when seen during eclipses.

Mathematical analysis of the way in which the gaseous material comprising the outer layers of the sun may be expected to thin out into space, more or less justifies this threefold division. Thus a definite temperature gradient believed to exist in the photospheric layers shades off into an approximately isothermal state in the chromosphere. Again, the local thermodynamic equilibrium in the photospheric layers shades off into strict monochromatic radiative equilibrium in the chromosphere. The reversing layers play the role of transition layers exhibiting great complexity of structure and behaviour. Theory also predicts the chromosphere as a very delicately balanced structure, and the least departure from exact balance is followed by catastrophic consequences. Indeed, the abrupt changes of form, position and velocity shown by *prominences*—the tongues of flame which often flare out of the sun—are doubtless phenomena caused by this delicate imbalance.

The corona, as well as the prominences, are features that are displayed outside the conventional solar 'atmosphere'. The form of the corona varies considerably in a manner which is closely associated with the sunspot cycle. At sunspot maximum the corona appears as an approximately symmetrical glow round the sun extending from half to one solar radius from the photosphere; but at sunspot minimum it displays long equatorial streamers extending to several solar radii, accompanied by polar plumes or tufts of light at the poles.

In the early years scientific study of the corona depended mostly on observations made during total eclipses of the sun, and by the turn of the century techniques of eclipse photography and eclipse spectrscopy had developed rapidly and solar eclipses attracted widespread and co-ordinated interest amongst astronomers of the world.

One of the earliest (1869) spectroscopic observations of the light from the corona was the well-known green line λ 5303 whose origin remained a mystery as the same could not be produced by any known element on the earth. The line was attributed to a new element 'coronium'. Now we know that it is due to the iron atom in a highly ionized state, *viz.*, Fe XIV ($^2P_{3/2}$–$^2P_{1/2}$) with an ionisation potential of 355 volts.

The development of a working coronograph by the French astronomer Lyot in the early thirties of the present century ushered in a new era in coronal science. In principle, the coronograph uses an occulting disc at the focus of the telescope to cut out the photospheric light, and by means of other optical devices enables the slit of the spectroscopic attachment to be illuminated by coronal light only. The perfection of the coronograph has enabled observational study of the corona to be made at all times. There are now nearly a dozen coronograph stations, many located at high altitudes, throughout the world which are in regular operation taking daily observations, in contrast to the few minutes' observations at total solar eclipses occurring decades apart.

The spectrum of the corona consists of a continuum produced by the scattering of the photospheric light by the coronal electrons, and superposed on this continuum is a bright line spectrum. Near the sun and at time of high sunspot activity the more intense of these lines may be 50–100 times as bright as the coronal continuum, which in turn is only a few millionths of the brightness of the photospheric continuum. The study of these lines—their identification, their variation in brightness with position in the corona and with the solar cycle, and the explanation of their presence and behaviour—constitutes a major part of coronal science.

Out of the entire list of lines, three are particularly useful for following the day-by-day

* *A Guide to the Solar Corona*. By D. E. Billings. 1966. Academic Press, New York and London. Pp. 323, Price $ 14·00.

changes in the corona. These are the red line λ 6374 of Fe X, the green line λ 5303 of Fe XIV, and the yellow line λ 5694 of Ca XV. They are in a very accessible part of the spectrum for visual observation or photography; they come from widely separated states of ionization—the ionization potential for Fe X is 235 V, for Fe XIV is 355 V, and for Ca XV it is 820 V. Thus the red gives information about the cooler portions of the corona, the green line on the regions of intermediate temperature and the yellow line on the hotter regions.

Various aspects of spectral studies of the corona like the width of coronal line profiles, the identification of the lines as due to highly ionized atoms, the absence of emission lines of hydrogen and helium which are the major constituents of the coronal material, the emission of X-rays and extreme ultraviolet rays by the corona, and above all the results of radio astronomical investigations of the corona, have confirmed the conception of a hot corona in the million degree range.

While the hot corona has solved many problems that were puzzles before, it has also created new problems that await understanding. These are: (1) the need of an adequate description of the heating mechanism; (2) our ignorance of the dynamic structure of the corona; (3) the apparent discrepancy between the chemical composition of the corona and the photosphere; (4) our surprising lack of understanding of the relation between the inner and the extended portions of the corona.

The book under review gives a comprehensive survey of the solar corona, including both observations and theoretical considerations. It will be a useful guide book to students and researchers as it considers not only established ideas but also reasonable speculation on the subject.

DECAY OF TANTALUM-182*

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TANTALUM-182 decays by negation emission with a half life of 115 days to W^{182}. The level scheme of W^{182} has been investigated by a number of workers.[1-4] Most of the levels, shown in Fig. 1, have been well established. A weakly fed level at 680 keV is not confirmed by some workers.[5] A very weak γ-ray of 1410 keV, reported by K. Korkman *et al.*,[5] does not fit into the present level scheme of W^{182}.

In the present study the level scheme of W^{182} has been investigated using a sum-peak coincidence spectrometer in almost 4π geometry.[6] The block diagram of the spectrometer is shown in Fig. 2. Since this spectrometer, when used in 4π geometry, has the highest coincidence detection efficiency and is almost insensitive to minor electronic drifts, it is considered to be a good tool for studying the weak and multiple cascading γ-rays as are encountered in the decay of Tantalum-182. The sum-peak coincidence spectrum, with integral bias settings of about 80 keV, is shown in Fig. 3 *a*. All the sum-peaks, showing up in this spectrum, except two peaks at 590 and 1810 keV, fit well with the reported γ-rays in W^{182}. The sum-peak at 590 keV shows up due to the summing of 351 and 229 keV γ-rays

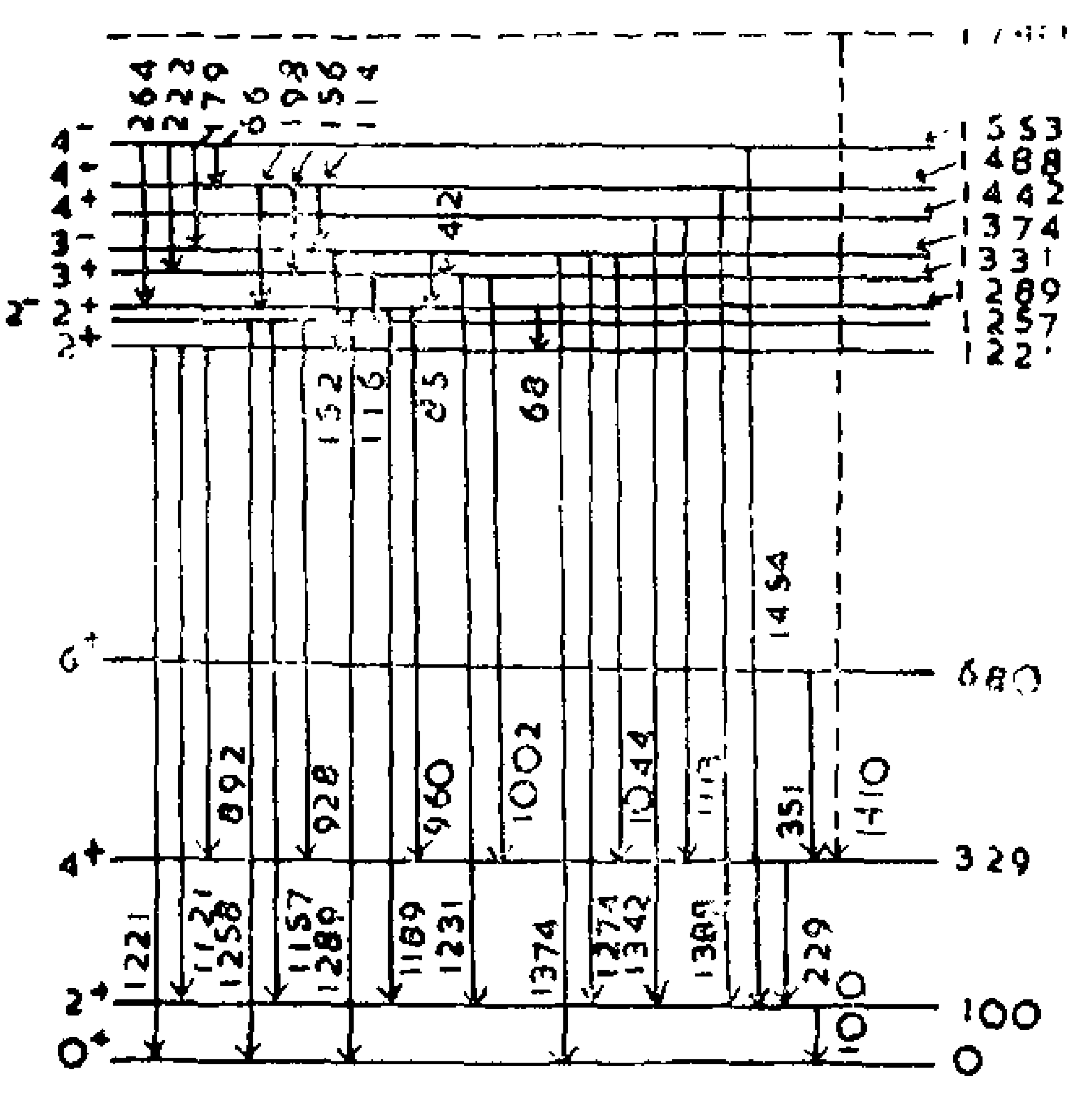

FIG. 1. Level scheme of Tantalum 182

of 351–229–100 keV cascade. This indicates the existence of a level at 680 keV which arises

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