Aluminium-Surfaced Mirrors in Astronomy

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IT appears probable that aluminium-surfaced mirrors will in time entirely displace silvered mirrors for investigations in the ultra-violet region of the spectrum and for astronomical purposes generally. The evaporation process dates back to the time of Edison who, in 1890, obtained patents in connexion with it. It was not until about 1928 that the advantages of the evaporation method for various scientific applications began to receive attention. At about this time, Hochheim, in Germany, evaporated an ultra-violet reflecting alloy consisting of 88 per cent of aluminium and 12 per cent of silver.

The process was perfected by R. Ritschl at the Reichsanstalt, particularly with the view of coating two interferometer mirrors simultaneously and equally to give the same reflecting power. The firm of Messrs. Adam Hilger, Ltd., was later instructed by Ritschl in the production of reflecting surfaces by the evaporation process. In the United States, the process was used in 1931 for small interferometer mirrors and filters by Dr. J. Strong, then of the University of Michigan, and Dr. P. G. Kruger, at Cornell University. Pure aluminium seems to have been first evaporated by Dr. Kruger. Dr. R. C. Williams suggested in June 1931 that the method be applied to large astronomical mirrors and tried chromium, which he found to give a hard, untarnishable film with fair ultra-violet reflectivity. The first astronomical application of the process was at the total solar eclipse of August 31, 1932, when a chromium-surfaced 15-inch mirror of the Lowell Observatory was used to obtain the spectrum of the corona.

Dr. H. Cartwright and Dr. J. Strong found that the evaporation process could be applied to many metals, including aluminium, antimony, beryllium, bismuth, calcium, chromium, cobalt, copper, gold, iron, lead, magnesium, nickel, selenium, silver, tellurium, tin and zinc; also to speculum metal and to substances such as quartz and fluorite. They protected a silvered surface with quartz, less than one wave-length in thickness, and found that it was quite immune from tarnishing when exposed to sulphuretted hydrogen. The coating of astronomical mirrors with aluminium was undertaken independently by Dr. Strong and by Dr. Williams in the autumn of 1932.

Some results obtained with these aluminium-coated mirrors have recently been published. With the 36-inch Crossley reflector, Dr. W. H. Wright has investigated the ultra-violet spectra of certain planetary nebulae. The principal lines

present can be divided into two groups, namely: $\lambda\lambda$ 3346, 3426 and $\lambda\lambda$ 3133, 3312, 3341 and 3445. In some nebulae the first of these groups is relatively strong; in others, the second group is strong. The two lines of the first group have been identified independently by Swings and Edlén and by Bowen, from theoretical considerations, as forbidden lines in the spectrum of Ne V. The slitless images of these lines are the smallest in the whole nebular spectrum, indicating a high degree of ionisation. The lines of the second group are permitted lines in the O III spectrum; other O III permitted lines which might be expected to be present are not shown. Bowen has remarked that all the permitted O III lines which appear in the nebular spectra represent either a transition from the $3d^3P_2$ term or a transition from a term to which an electron can jump directly from this $3d^3P_2$ level. As the intensity variation of these lines from nebula to nebula follows the behaviour of the H II λ 4686 line more closely than that of the forbidden O III $\lambda\lambda$ 4959, 5007 lines, and as they are never observed when the λ 4686 line is missing, Bowen suggests that they are produced by fluorescent excitation. The $(2p)^2\ ^3P_2 - 2p3d\ ^3P_2$ transition of O III coincides closely with the resonance line of He II at λ 303.78. A quantum of this He II line can therefore disappear by excitation of an O III atom to the $3d^3P_2$ state.

The 15-inch mirror of the Lowell Observatory was aluminised by Williams and Sabine in August 1933, and the ultra-violet spectra of 97 stars, to the ultra-violet limit of atmospheric transmission, were photographed at the mountain station of the Observatory on San Francisco Peak at a height of 11,500 feet. The Huggins bands of ozone and additional bands to the ultra-violet were prominent. The microphotometer energy curves have been used for the derivation of the temperatures of the stars.

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