measured photoelectrically at Mount Wilson. The previous colors in clusters of nebulae reported by Stebbins and Whitford¹ showed an unexplained color excess, but the objects measured were all elliptical nebulae, and therefore represented pure population II. The spiral objects in the Corona Borealis cluster were selected as the most remote examples of population I with a known distance; spirals have not been resolved in the Bootes cluster. For the four ellipticals the international color excess is +0.28 mag., of which 0.15 mag. is not accounted for by the red shift. Intermediate type spirals also show a residual excess, but the interpretation is clouded by uncertainty about the classification. The four spirals classified as type Sc, with the largest proportion of population I, show a mean excess of +0.09 mag., which with a calculated red-shift effect of +0.15 mag., leaves a residual of -0.06 mag. The negative residual is probably not significant, on account of the intrinsic color dispersion of the objects and the observational difficulties in measuring faint diffuse spirals. But the difference between ellipticals and late spirals favors the hypothesis that the unexplained excess is a time effect in population II, as suggested by Schwarzschild, and not a space-reddening effect caused by intergalactic material. The red supergiant stars which have burned themselves out and faded in nearby ellipticals, but which were present 130 million years ago in the Corona nebulae, would add only slightly to the mass and to the photographic luminosity. In evaluating nebular counts to the faintest magnitude limits, however, a very appreciable luminosity correction would be necessary, particularly on red plates.

1. *A. J.* 53, 206, 1942; *Ap. J.* 108, 413, 1948.

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Wildt, Rupert. Continuous absorption by interstellar molecules.

Certain diatomic molecules possibly quite common in interstellar space deserve attention for their continuous absorption, although such spectra are not strong enough to affect interstellar absorption, as the term is understood in relation to the apparent magnitude of distant stars. However, the photodissociation resulting from such molecular absorption might be important among the processes by which the radiant energy of interstellar space is brought into interaction with the kinetic energy of its gaseous

population. The relevance of continuous molecular absorption to the problem of the kinetic temperature of interstellar matter was recognized by L. Spitzer, Jr.¹ This note deals mainly with two interesting hydrogen spectra not mentioned by Spitzer.

Both ionized and neutral hydrogen molecules have continuous absorption spectra between $\lambda 1000$ and $\lambda 3000$, involving the following transitions:

and

The first spectrum is the dissociation continuum of the ground state of H_2^+ . The second spectrum is an association continuum: two colliding hydrogen atoms in their ground states, provided their electronic spins are parallel, constitute an unstable molecular state which can be transformed into a stable excited state by absorption of a suitable photon. Both spectra are of great intrinsic strength, the f -value summed over all frequencies being nearly 1 for H_2^+ and probably between 1 and 2 for H_2 . Hence H_2^+ is highly susceptible to decomposition even in the $H\text{ I}$ regions of interstellar space, since it is not protected against photodissociation by the Lyman continuum of atomic hydrogen. Formation of H_2^+ occurs by collision between H and H^+ , followed by emission of a photon: this is one of the rare cases in which recombination into the ground state by double collision is permitted under the electronic transition rules. Recombination of two hydrogen atoms into the ground state of H_2 is feasible only by a triple collision and, therefore, must be quite exceptional in interstellar space. On the other hand, H_2 in its singlet ground state is well shielded against photodissociation and photoionization by the Lyman continuum, as Spitzer pointed out. Because triplet-singlet transitions are forbidden in such light molecules as H_2 , the excited triplet molecules originating from photoassociation must have a very short life-time, decomposing spontaneously via the lowest (unstable) triplet state. Considered genetically, the hydrogen molecules of interstellar space fall into two classes, viz. singlet molecules, which may be rare, but should be stable, and triplet molecules, which should be common in $H\text{ I}$ regions, though rather short-lived.

The optimum rate of formation of H_2^+ is obtained if protons and hydrogen atoms are present in amounts of the same order of magnitude. Hence the existence of H_2^+ is practically restricted to the narrow transition zones between the $H\text{ II}$ and $H\text{ I}$ regions of interstellar space, and consequently the formation and decay of H_2^+ should not be of great importance in evaluating the kinetic temperature of the bulk of interstellar matter. Further discussion of the H_2^+ -effect must await completion of the work on the continuous absorption coefficient of this molecule, which is now being undertaken by Prof. Massey and Dr. Buckingham. Transition probabilities and mean life-times for the four lowest vibrational states of the $^3\Sigma_g^+$ level of H_2 have been derived by A. S. Coolidge, H. James and R. D. Present.² A naive application of the Franck-Condon principle would lead to the expectation that a marked transfer of energy from the interstellar radiation field (by the association continuum) to the kinetic energy of the hydrogen gas (by the spontaneous dissociation of the excited triplet molecules) could take place, because absorption of photons would occur on the average at greater nuclear distances (consuming photons of higher frequencies) than re-emission (generating photons of lower frequencies). But the rigorous analysis of Coolidge, James and Present indicates that re-emission from the excited vibrational states occurs predominantly from the outer part of the potential curve, thus producing again high-frequency radiation and low kinetic energy of the receding atoms. Loss and gain of the kinetic energy of the atomic hydrogen appear largely to cancel, and qualitatively one must conclude that the transitory existence of the triplet molecules does not appreciably raise the kinetic temperature of the hydrogen gas. A quantitative test of this surmise would demand laborious numerical integrations for various sets of assumed kinetic temperatures and energy curves of interstellar radiation. It would also be necessary to extend the work of Coolidge, James and Present to the transition probabilities for the higher vibrational states, which are reached by absorption of interstellar radiation of wave lengths shorter than 2000.

Another hypothetical constituent of the $H\text{ II}$ regions are HeH^+ molecules, which could be formed by collisions between protons and unexcited helium atoms. According to quantum mechanical computations these molecules have a stable ground state with a dissociation energy

of 1.1 volt,³ and in fact they have frequently been observed in the mass spectrograph. By capture of an electron HeH^+ would dissociate, as the ground state of the neutral helium hydride is unstable. No spectrum of HeH^+ has so far been observed in the laboratory, and little is known about the theoretical energy level diagram.

1. *Ap. J.* **107**, 6, 1948.

2. *Phys. Rev.* **55**, 184, 1939.

3. S. Toh, *Proc. Phys. Math. Soc. Japan* **22**, 119, 1940.

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Williamson, Ralph E. and G. F. D. Duff. On the role of the guillotine factor in stellar structure.

Integration of five point-source models for late type main sequence stars have been performed, the guillotine factor being taken to vary with different powers α of the density. Certain transformations of the equilibrium equations into a form convenient for numerical work are given. The central conditions and chemical compositions of late-type main sequence stars, on the basis of these models, are found to depend sensitively upon the representation of the guillotine factor; for this reason no definitive conclusions regarding them can be drawn from these models. Indications are that values of $\alpha \approx 0.50$ are suitable, and that central temperatures are slightly lower, and densities noticeably higher, than the Cowling model. The carbon cycle is probably the predominant source of energy, and on this basis, it is found that hydrogen and helium contents are rather higher than those indicated for the sun. Suggested refinements to the models are representation of the guillotine factor proportional to two different powers of the density in the inner and outer portions of the radiative envelope, and allowance for deviations from the perfect gas law due to degeneracy.

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Wood, Frank Bradshaw. The eclipsing variable, RX Herculis.

The variability of RX Herculis was discovered by Sawyer in 1898. Since then, it has been observed visually, photographically, and spectrographically; this is the first photoelectric study. This study is based upon 323 photoelectric observations taken in the summer of 1947 with the 12-inch refractor of the Lick Observatory and a photomultiplier photometer constructed by G. E. Kron.