

REFERENCES

- ¹ E. MAYER and L. HELMHOLTZ,—*Zeits. f. Phys.*, vol. **75**, p. 19, (1932).
- ² MAX BORN and E. MAYER,—*Zeits. f. Phys.*, vol. **75**, p. 1, (1932).
- ³ M. N. SAHA and R. SHARMA,—*Bull. Acad. Sc. U.P.*, vol. **1**, p. 119, (1931-32).
- ⁴ ANGERER and MÜLLER,—*Phys. Zeits.*, vol. **26**, p. 643, (1925).
- ⁵ E. LEDERLE,—*Zeits. f. Phys. Chem. B.*, vol. **17**, pp. 84, 85, 353, (1932).
- ⁶ H. KUHN,—*Zeits. f. Phys. Chem.*, vol. **19**, p. 227, (1932).
- ⁷ Oldenberg,—*Phys. Rev.*, vol. **43**, p. 534, (1933).
- ⁸ J. E. MAYER,—*Zeits. f. Phys.*, vol. **61**, p. 798, (1930).
- ⁹ P. P. SUTTON and J. E. MAYER,—*Jour. Chem. Phys.*, vol. **3**, p. 20, (1935).
- ¹⁰ GIBSON and HEITLER,—*Zeits. f. Phys.*, vol. **49**, p. 465, (1928).
- ¹¹ M. N. SAHA and A. N. TANDON,—*Proc. Nat. Acad. Sc. India*, vol. **6**, p. 212, (1936).
- ¹² FIÖCH and RODEBUSH,—*Jour. Am. Chem. Soc.*, vol. **48**, p. 2552, (1926).
- ¹³ WARTENBURG and SCHULZ,—*Zeits. f. Elec. Chem.*, vol. **27**, p. 568, (1921).
- ¹⁴ M. N. SAHA and B. N. SRIVASTAVA, A Treatise on Heat, p. 703.

66. MOLECULES IN INTERSTELLAR SPACE ?

(Nature, **139**, 840, 1937)

In a recent note in NATURE¹, and more in detail elsewhere,² Dr. T. Dunham, jun., has described his discovery of more interstellar lines due to K ($\lambda 7699.03$), Ca ($\lambda 4227$), Ti⁺ ($\lambda 3242.6$ and others) and a number of other lines the origin of which has not yet been traced ($\lambda 3957.7$, $\lambda 4300.3$, $\lambda 4232.6$). We have to add to these Merrill's interstellar lines³ ($\lambda 5780$, $\lambda 6284$).

Dunham's work and his discussion of the occurrence of Ti⁺-lines forms a landmark in the story of interstellar investigations, as it throws clear light on the mechanism of excitation, and removes a good deal of misconception arising out of the former idea that only Ca⁺-lines, and the sodium D-lines occur in interstellar space.

Dunham's discovery that only such Ti⁺-lines which arise from absorption in the lowest orbit of Ti⁺ ($3d^2. 4s. 4F_{3/2}$) occur as interstellar lines and that no Ti⁺ atom in the next excited state Ti⁺ ($3d^2. 4s. 4F_{5/2}$ excitation potential 0.012 volt) occur in interstellar space, shows that the reaction between matter and radiation in interstellar space is of a kind which cannot be described in terms of any interspace temperature. The temperature in interspace is very nearly absolute zero, and ionization is produced only by the photochemical action of quanta meeting atoms or ions after long intervals of time in space. The recombination between ions and electrons also take place at very long intervals. The result is that only such states of atoms and ions occur in interstellar space as have infinitely long life.

The argument raises the question: Why should not molecules also occur in interstellar space? In fact, the

above arguments, if forced to their logical conclusion, lead us to the view that we should have molecules in interstellar space. Merrill in fact notes that the lines $\lambda 5780.4$, and $\lambda 6284.0$ discovered by him are diffuse, and in course of a conversation told me that they might be molecular in origin. In fact, the line $\lambda 6283.0$ appears decidedly to be due to *molecular sodium*, Na₂, due to the transition (Na₂: $2S^2S A 1\Sigma \rightarrow 2S. 2P B 1\Sigma, n''=0, n'=8$). This band is obtained in absorption in molecular sodium, and according to the Franck-Condon principle, the transition is strong as r'' (internuclear distance at the lowest state) is 3.07×10^{-8} cm., and r' (internuclear distance at the excited state) in 3.66×10^{-8} cm., so the transition $n''=0$ to $n'=8$ is the most probable. According to the arguments presented here, no other line (or band) of Na₂ is likely to occur among the interstellar lines.

Merrill's other line ($\lambda 5780$) may be provisionally identified with a line of NaK ($n''=0, n'=5$), though in this case the identification is less sure.

The molecule which is likely to be most abundant in interstellar space is H₂, but as it gives absorption lines only in the Lyman region, there is no possibility of our being able to prove its existence, but lines due to hydrides may be found amongst interstellar lines.

Department of Physics,
University, Allahabad.

April 6.

¹ NATURE, **139**, 247 (1937).

² Pub. Ast. Soc. Pac., **49**, 26 (1937).

³ Pub. Ast. Soc. Pac., **48**, 179 (1936).