secondly, how it is possible to compare models which do not describe the same phenomena. For Milne’s model is constructed precisely to describe the phenomenon of the recession of the nebula, the Einstein model precisely to describe a state of affairs in which this phenomenon is absent. Milne could, in exactly the same arbitrary fashion, have identified his model with any one of the “expanding universe” models of general relativity: he would then have concluded that his $\frac{1}{t^2}$ is not the counterpart of the cosmical constant.

A comparison between Milne’s model and the general relativity models can evidently be made for the limiting cases of the latter, provided (b) is also satisfied. For if matter is negligible, so also are the effects produced in it by an arbitrary assignation of space and time: thus rule (A) approximately becomes rule (B). In fact, it has been demonstrated* that the general relativity model corresponding to Milne’s is not the Einstein universe but an expanding universe in which $\lambda=0$. $ct$ is then the counterpart of the “radius of visibility” of any particle: a feature common to all relativistic models. For the above reasons, I submit that Milne has given no valid grounds for altering this conclusion and for supposing that his $\frac{1}{t^2}$ can be interpreted as the cosmical constant.

I am, Gentlemen,

Yours faithfully,

G. C. McVittie.

The University, Edinburgh.


The Relation between the Chromosphere and the Prominences.

GENTLEMEN,—

In my paper on the “Solar Chromosphere” (M. N. 94. 14, 1933, referred to in the following as loc. cit.) I indicated very briefly the probable origin of the two types of prominences—tornado and quiescent prominences—which are very definitely features of the normal chromosphere. In this letter I wish to sketch in outline a general method by which one could make an approach towards a more definite theory of these prominences and which also incidentally explains their comparative stability and permanence.

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On the assumption of the uniqueness of the velocity components in the \((\xi, \zeta)\)-plane* we have shown that the density distribution consistent with the hydrodynamical equation of continuity is specified by

\[
\rho = \Phi \left\{ \sin \xi + \frac{\alpha}{\beta} \int_0^\zeta \xi K_1(\xi) d\xi \right\}, \quad \ldots \quad (1)
\]

where \(\Phi(x)\) is an arbitrary function of the argument \(x\), and \(\alpha/\beta\) is a constant of the atmosphere (§13, loc. cit.). Apart from the one special type of density distribution which we have already discussed in loc. cit. in connection with the density gradients occurring in the general chromosphere, there exists in reality an infinite variety of other possible types of density distributions in accordance with (1).

Thus, to take one particular case, we could have

\[
\rho = \rho_0 \left\{ \sin \xi - \frac{\alpha}{\beta} \int_0^{\xi_1} \xi K_1(\xi) d\xi \right\}, \quad \ldots \quad (2)
\]

where \(\xi_1\) and \(\xi_2\) are arbitrary constants. The density distribution specified by (2) vanishes on both the trajectories

\[
\sin \xi = \frac{\alpha}{\beta} \int_0^{\xi_1} \xi K_1(\xi) d\xi = \frac{\alpha}{\beta} Q(\xi_1, \zeta), \quad \ldots \quad (3)
\]

and

\[
\sin \xi = \frac{\alpha}{\beta} \int_0^{\xi_2} \xi K_1(\xi) d\xi = \frac{\alpha}{\beta} Q(\xi_2, \zeta), \quad \ldots \quad (4)
\]

and further the density is positive only in the domain bounded by these two trajectories.

Three (mathematically) distinct cases arise:

Let \(\xi_2 > \xi_1\)

\[
\frac{\alpha}{\beta} Q(\infty, \xi_1) > \frac{\alpha}{\beta} Q(\infty, \xi_2) > 1, \quad \ldots \quad (I.)
\]

\[
1 > \frac{\alpha}{\beta} Q(\infty, \xi_1) > Q(\infty, \xi_2), \quad \ldots \quad (II.)
\]

\[
\frac{\alpha}{\beta} Q(\infty, \xi_1) > 1 > Q(\infty, \xi_2), \quad \ldots \quad (III.)
\]

* The notation is the same as in loc. cit., to which the reader is referred. In what follows a detailed knowledge of the analysis contained in that paper is presupposed.
Case I.—In this case both the trajectories (3) and (4) belong to the completely periodic type of solutions and would give rise to floating filaments of matter. Depending on the value of $\alpha/\beta$ (i.e. depending on the value of the unique downward vertical velocity of the atoms in these “floating chromospheres”), it is possible to have widely different shapes for these filaments. Thus if for a given $\alpha/\beta$, $\xi_2$ be widely different from $\xi_1$, then the resulting configuration would have an appearance similar to that of a quiescent prominence. If $\xi_2$ and $\xi_1$ are only slightly different, then we could either have a fairly “horizontal” low-lying filament or an arched type of prominence similar in its general form to the outer boundary of a quiescent prominence. An examination of the photographs of the prominences published by Pettit (Ap. J. 76. 9, 1932, see particularly plates I and II) indicates that all these three types do occur in Nature.

Case II.—This corresponds to both the trajectories (3) and (4) going off to infinity. As we have already suggested in loc. cit. we have here a probable origin of the more common type of “tornado” prominence. Of course, we have now attempted to set up a steady state density distribution for these prominences.

Case III.—In this case the trajectory (3) belongs to the completely periodic type of solution, while trajectory (4) goes off to infinity. We have here probably an explanation of the less common type of “tornado” prominence. Thus Pettit (plate I in his paper already referred to) has published the photograph of a remarkable case, where, according to him, “the angular velocity became so high that the prominence reached an unstable state and exploded.” According to the views developed here, there is no question either of “instability” or of an “explosion” but a simple dynamical consequence of the initial height at which the “tornado” started. The atoms at the upper edge of the “tornado” described trajectories (near (4)) going off to infinity, while those at the lower edge (as a consequence of the lower level at which they started off) described arcs along the trajectories belonging to the completely periodic type of solution.

In considering the differences between the “tornados” corresponding to Case II and those corresponding to
Case III, one should bear in mind that the curve of maximum density defined by the equation

\[ \sin \xi = \frac{1}{2} \frac{\alpha}{\beta} \{Q(\xi_1, \xi) + Q(\xi_2, \xi) \} . \ldots \quad (5) \]

will remain in the finite plane or go off to infinity according as

\[ \frac{1}{2} \frac{\alpha}{\beta} \{Q(\infty, \xi_1) + Q(\infty, \xi_2) \} > \text{or} < 1. \ldots \quad (6) \]

There should be therefore a continuous transition between the two types of "tornados".

We could perhaps deal with more complicated situations by considering more general forms for \( \rho \) than (2). There is, however, no need to go into these details in this general sketch, but from what has been said it should be obvious that there can be, in principle, no well-defined demarcation between the chromosphere, the quiescent prominences and the "tornados". This requires to be emphasized, since the very close relation between the chromosphere and the prominences is also a fact of direct observation.

I am, Gentlemen,

Trinity College, Cambridge, 1934 January 10.

Yours faithfully,

S. Chandrasekhar.

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Extension of the Photographic Image with Length of Exposure Times.

Gentlemen,—

With reference to the discussion of my paper at the R. A. S. meeting on January 12, reported in this issue, I should like to add that there seems to be some misconception as to the effect of long exposures on the spiral and elliptical nebulae. It is of course true that a short exposure will only bring out the nuclear regions, but it is equally true that a prolonged exposure will only extend the diameter to a superior limit, beyond which no extension can be obtained by prolonging the exposure still further. As an example, no exposure with any instrument has appreciably increased the angular dimensions of the Andromeda Nebula beyond those shown in the well-known photograph by Ritchey with a 24-in. Reflector, 93-in. f.l., exposure 4 hrs., at the Yerkes Observatory. The measurement of radiation by photoelectric cells is a method