got rid of by radiation, and the radiation L is fixed by the mass and (to a comparatively small extent) the radius of the star. By hypothesis, E cannot be altered by a change in the physical conditions, so that the star must adjust its radius to bring L to the right amount. If initially $E>L$ the star is gaining energy and therefore expanding; the physical theory indicates that an increase of radius diminishes L, so that the discrepancy becomes worse. The star expands indefinitely.

The first objection is particularly evident when applied to the components of double stars which must contain material of the same age and, therefore, of the same degree of exhaustion. The hypothesis requires that these shall emit energy proportionately to their masses—a result which is not verified. The particular case of the sun and the earth is referred to by Dr. Jeans, who meets the objection with a suggestion that the material forming the earth was not an average sample of the material of the sun at the time of separation. A short time ago I would have admitted this possibility; but I have recently found (in an article in the *Observatory* for March) that the rotation of a star must necessarily lead to circulatory currents in the interior which would keep the material well mixed. The argument is based on an extraordinarily general formula discovered by H. von Zeipel, and I do not think the conclusion can be evaded. It follows that when a star divides, each part has the same chemical composition, and if Jeans's rule were true the two parts would continue to be similar through all subsequent time.

It is very difficult to find a law of liberation which will satisfy astronomical requirements. In abandoning the contraction hypothesis we seem to have jumped out of the frying-pan into the fire—not that I see any conceivable prospect of returning to our former refuge. A direct dependence of the rate of liberation on density and temperature seems to be ruled out. On calculating the numerical magnitudes concerned (after taking into account all possible exhaustion-effects), it is found to give the star a kind of over-stability which would rapidly magnify the smallest disturbance into a large pulsation. This pulsation is supposed to occur in cepheid variables, but these are limited to a well-defined range of mass and density. With the hypothesis here considered cepheid variation would be more widespread.

At present, I see no insuperable objection to the following hypothesis; I scarcely recommend it in its present form, but some theory on these lines seems to be the one way out of an almost hopeless deadlock. We must consider two processes: one of evolution, the other of disappearance, of certain destructible forms of matter. The former is supposed to be dependent on density and temperature: the latter to be independent. It must be understood that the two processes are not the reverse of one another. The first is a transmutation absorbing or releasing comparatively little energy; the second is an annihilation of matter releasing great quantities of energy. The first is a synthesis involving the bringing together of constituents; its rate therefore depends on physical conditions. The second is a spontaneous degeneration in which only an isolated atom is concerned. The destructible elements are supposed to have lives ranging from a few minutes to many years, but most of the released energy comes from the long-lived products. A quiescent star will be in a steady state, except for the slow alteration of mass; the amount of self-destroying material and consequent generation of heat is thus dependent on temperature and density. Pulsation of the star will affect the rate of liberation only through the short-lived products; it should thus be possible to obtain stability without over-stability. It is necessary to admit exhaustion-effects also in this scheme, in order to reconcile, for example, the rapid liberation of energy in Capella with the slow liberation in the sun, notwithstanding the higher temperature and density in the latter.

I believe it is widely thought that the comfortable phrase *sub-atomic energy* ought to make the astronomer entirely happy; it gives him a long enough time-scale, and all is plain-sailing. Attempts to guess the *modus operandi* are regarded as mere speculation in an unlimited field. No doubt it is highly speculative to try to predict the processes by extrapolation of the modern theories of atomic physics; but the approach from the astronomical side is merely the prosaic procedure of empirically deducing unknown laws from observational data. Stellar astronomy is largely occupied with determining the rate of liberation of the mysterious source in conditions of temperature and density (both static and disturbed) which are now reasonably well known. Either the astronomer must leave this mass of data uncorrelated, or he must try to feel his way towards the disentanglement of the unknown agencies.

A. S. EDDINGTON.

Observatory, Cambridge,
March 4.

The Ages and Masses of the Stars.

CONCERNING Mr. Schumann's comments (NATURE, January 24) upon Dr. Jeans's paper (December 6) on "The Ages and Masses of the Stars," I should like to direct attention to the point of view expressed in my paper on "The Age of the Stars" which was read before the National Academy of Sciences on November 11 last, a few days before the meeting at which Dr. Jeans presented his work to the Royal Astronomical Society. It was there emphasised that the decrease of mass as a result of radiation is a necessary consequence of the theory of relativity. If relativity be accepted this must be so, independently of the mechanism involved in the change of mass as *matter* into mass as *radiation*. The fact that a star radiates means that it loses mass in this way: whether all the mass lost is lost by radiation is another matter. My paper, which is to appear in the Proceedings of the National Academy of Sciences for February, goes into the point more fully than I can here.

EDWARD CONDON.

Physics Department, University of California,
February 14.

Late Palæolithic Art in the Cresswell Caves.

No one could welcome the results of Messrs. Garfitt and Armstrong's exploration of Cresswell Crags more than I do myself, especially as they relieve the Palæolithic inhabitants of these islands from the unmerited reproach of an indifference to art. I only wish they had been made in time for recognition in the last edition of "Ancient Hunters."

In the light of these recent discoveries, the problem of the Cresswell "horse" assumes quite a different aspect, and I feel all the more bound to offer an explanation of the statement for which I am responsible, referred to by Sir W. Boyd Dawkins in NATURE of March 7, p. 336. It arose out of a conversation with the Rev. A. M. Mullins, rector of Langwith-Bassett, well known by his exploration of the Langwith Cavern, which is situated within easy reach of Cresswell Crags. Happening to refer to the almost complete absence of any artistic work in the Palæolithic deposits of this country, I mentioned