so that within the limits of uncertainty in every case the distribution of the stars is consistent with a solution of the above differential equation when γ is assigned the value 1·2.

The analogy between the distribution of stars in a condensed cluster and the density in a spherical mass of gas of a particular type in adiabatic equilibrium thus seems to be fairly established. Even if it be supposed that the cluster is the outcome of an original nebula the question still remains why the distribution of matter should persist long after its condition has completely changed, or why the arrangement should resemble what might be expected of certain vapours (*e.g.*, chloroform). The answer given by v. Zeipel on the basis of a strict mathematical analysis is that this is in conformity with a kinetic theory which applies to an aggregate containing a high proportion of Keplerian binaries. This may be a bold application of the law of large numbers, but it is certainly an interesting conception. Since there is every reason to believe that all short period variables are binary systems the observed occurrence of these in clusters lends support to the view, though they can only represent the exceptionally close systems. The investigations here described refer exclusively to the highly condensed clusters. But there exist also clusters showing states of concentration in varying degree until probably all visible trace of organic connection is lost. In Strömgren's view the whole series represents an order of evolution by which the dense clusters grow out of more scattered forms. Whether the results will throw light on the wider problems of the structure of the sidereal universe seems doubtful in view of certain conclusions drawn by Poincaré, Jeans and Eddington as to the relevance of the kinetic theory. But taken by themselves they present questions of the highest interest which are likely to repay further study. H. C. PLUMMER.

ON COLOUR SENSITISED PLATES.

I.—IN GENERAL AND ORTHOCHROMATIC PLATES.

IT used to be customary to draw three curves above a diagrammatic spectrum, heat, luminosity, and actinism curves, the last representing the power of light to produce or facilitate chemical change independently of the temperature change. This custom survives to a certain extent, though only one of the curves, namely, the heat curve, is definite. The luminosity curve depends upon the human eye, and eyes vary, sometimes even in the same individual, with regard to their sensitiveness to light and colour. Still, it is possible to draw practically useful luminosity curves in a general sense, and by taking an average human eye, in perhaps almost an absolute sense.

But the "actinism" curve is essentially different, for here we may be concerned, not with a single organ and its possible variations or degrees of perfection, but with every substance that exists on the face of the earth or that can be prepared by artificial means. And if we limit our considerations to the very few substances that are practically utilised in photography, we find that "actinism" extends from well into the infra-red down to the Röntgen rays, which are far below what is generally known as the ultra-violet. "Actinism" extends over a range of eleven or twelve octaves for practical photographic purposes, while luminosity extends over scarcely one octave, and for practical purposes even less than this, and yet some people speak of the photographic plate as colour-blind!

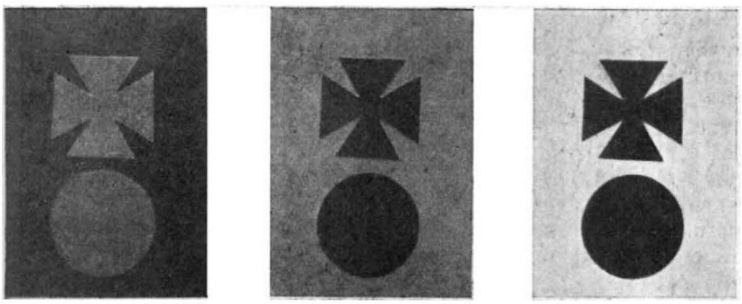
The whole of this eleven or twelve octaves has not yet been dealt with photographically, because in the extreme ultra-violet (the "Schumann region") at wave-lengths a little less than 200 $\mu\mu$, the absorbing power of air and gelatine prevents the passage of radiations through them. But this appears to be due to absorption bands, as radiations of still shorter wave-length (Röntgen rays) pass freely through these media. By getting rid as far as possible of air and gelatine, the photography of the ordinary spectrum has been extended down to wave-length 100$\mu\mu$, or even less. There are other difficulties than the air and gelatine to contend with in investigations of this region, but with these we are not immediately concerned.

Although it is necessary sometimes to bear in mind the enormous range of sensitiveness of photographic materials, even from a purely practical point of view, if we exclude the Röntgen region, and regard only those circumstances that concern the photography of objects, whether terrestrial or celestial, and whether by daylight or artificial light, we have to consider only about two octaves of radiations, or rather more if the far infra-red is taken into account. This range may be still further curtailed when daylight or glass apparatus is used, on account of the absorptive power of glass and the atmosphere, and what remains may often be sufficiently described by indicating five regions, namely, ultra-violet, blue, green, red, and infra-red. The "blue" will include the indigo and violet, and the "red" will include the orange, and the yellow is negligible as in a good spectrum it is represented by little more than the sodium D lines.

In order to photograph coloured objects so that their luminosities shall be correctly represented in the print, we want to get the curve that represents the action of the spectrum on the plate to coincide with the luminosity curve of the spectrum, and then we want a printing method that will preserve these tone values. The alternative of getting equal and opposite errors in the negative and the print so that the one shall correct the other, may have a degree of possibility about it. The fact to be emphasised is that the getting of a correct negative is not the whole business. Indeed, the getting of the two curves to correspond is not the whole business so far as the negative is concerned, for they may correspond at one exposure of the plate to the spectrum and not at another, because the steepness of the gradation of the deposits produced on the plate by equivalent ranges of exposures to the various parts of the spectrum is not the same. These difficulties are mentioned to show that, from a practical point of view, "ortho-

chromatic" or "isochromatic" photography, or whatever it may be called, cannot yet even be regarded as an absolute matter; but where the discrepancy in the use of "ordinary" plates is of the order of a thousand to one, there is plenty of room and need for improvement, before getting, as it were, within sight of perfection.

When the spectrum is photographed on an ordinary plate, the green and red, which are bright to the eye, produce little or no effect; they might as well be black, while the blue and ultra-violet, which are dark and black to the eye respectively, produce a considerable effect, as if they were bright. Similar results are obtained with ordinary objects; slate roofs, being bluish, come much too light; bricks, being red or reddish, come much too dark; grass and green foliage too dark, and so on. The plate is sensitive to all these colours, but it is very much too sensitive to blue, or not sensitive enough to green and red. By causing the light that falls upon the plate to pass through a colour filter that will reduce the brightness of the blue light to about one-thousandth part of its intensity, and increasing the exposure proportionately, the green and red will be given an opportunity to act, and the result will be much improved. To increase exposures to one thousand times the usual length may sometimes be possible (say two minutes instead of the tenth of a second), but the undesirability of such an increase need not be pointed out.



Ordinary Plate. Iso- Plate without screen Iso- Plate with screen.

FIG. 1.

Dr. H. W. Vogel, in 1873, discovered that by the application of certain colouring matters, it was possible greatly to increase the sensitiveness of plates to green and red light. About ten years later the application of this principle began to be made a commercial matter, and Messrs. Edwards and Co. secured the patent rights in this country. These isochromatic or orthochromatic plates were a great step in advance. The three illustrations (Fig. 1) were prepared many years ago from a design for which the writer was indebted to Mr. B. J. Edwards. The cross and the disc in the original are of such dark shades of blue, that from a distance of from one to three yards, according to the sensitiveness to blue of the eyes of the person looking at the card, they appear quite black, while the ground colour is a bright yellow. On the ordinary plate the yellow comes out darker than the almost black blue. The improvements obtained by using an orthochromatic plate, and then by the use of a colour filter to reduce the blue light in proportion to the yellow, are shown in the reproduction.

There are two or three matters in connection with the use of such means as these to get variously coloured objects represented according to their luminosities that may be pointed out as well from this example as from any other, bearing in mind that they represent general principles. Such plates as these ("ortho-" or "iso-chromatic") are often, if not generally, stated to be sensitive to yellow. This is misleading. Spectrum yellow, as already stated, is negligible in these matters. All objects that are yellow are yellow because they absorb blue, and send red and green light to the eye. Yellow light is a mixture of red and green. These plates have their sensitiveness increased to green and not to red. If, therefore, we so arrange our colour filter as to get full correction for yellow, that is, that yellow and blue shall be correctly represented according to their luminosities, we throw the correction that ought to be borne by the green and red jointly entirely on to the green, and this colour is therefore over-corrected. Greens will therefore be represented too light. On the other hand, the increased sensitiveness does not extend over the whole of the green, it is chiefly in the yellowish-green, and the curve of sensitiveness shows an important depression in the region that may be roughly indicated as being between E and F. Pure yellowish-greens tend, therefore, to be over-corrected on this account also, but what is perhaps of more importance is that a green that comes in this depression of sensitiveness will be under-corrected and come out too dark. This is not a mere theoretical difficulty, for M. Callier, who is a most careful investigator, finds that the green of pine trees largely corresponds to this deficient sensitiveness, while that of grass corresponds rather to the specially sensitised yellowish-green. Therefore these two greens are represented as more different in brightness than they really are.

These facts illustrate the difficulties that result from the fact that specially sensitised plates have not an evenly graded sensitiveness. There is the maximum for the plate, and a new maximum for the new compound introduced. Such irregularity might be compensated by a complex colour filter, but of course only approximately and with much trouble and considerable increase of the necessary exposure.

The "ortho-" or "iso-chromatic" plates of commerce are generally of the type just discussed, and are sensitised by erythrosin or a similar substance. In a second article we shall refer to "panchromatic" plates and other matters.

CHAPMAN JONES.