British Central Africa, presented by Captain C. F. Beeching; a Raven (*Corvus corax*) British, presented by the Rev. F. C. A. Barrett; a European Pond Tortoise (*Emys orbicularis*), European, presented by Miss W. Fenwick; a Common Marmoset (*Hapale jacchus*) from South-east Brazil, a Burchell's Zebra (*Equus burchelli*), born in the Menagerie, deposited; two Red Foxes (*Canis fulvus*) from Canada, a Black Woodpecker (*Picus martius*), a Hoopoe (*Upupa epops*), four Little Ringed Plovers (*Ægialitis curonica*), European, purchased.

OUR ASTRONOMICAL COLUMN.

THE CAUSE OF THE PROPER MOTIONS OF STARS.—When the parallax of the star 1830 Groombridge is considered in connection with the large proper motion of seven seconds of arc per annum, the conclusion is arrived at that the star is moving through space with a velocity which probably exceeds two hundred miles per second. In his "Popular Astronomy," Prof. Simon Newcomb briefly discussed the problem of stellar dynamics involved in this enormous velocity. He showed that if the universe be considered of such an extent that light would take 30,000 years to cross it, and if it contained one hundred million stars, having, on the average, a mass five times the mass of the sun, the gravitational attraction of a universe thus constituted would only be sufficient to give a velocity of twenty-five miles per second to a body drawn from infinity to the centre of the system of masses. The calculated limit is thus only about one-eighth the velocity deduced from the observed proper motion and parallax. Prof. Newcomb therefore concluded: "Either the bodies which compose our universe are vastly more massive and numerous than telescopic examination seems to indicate, or 1830 Groombridge is a runaway star, flying on a boundless course through infinite space with such momentum that the attraction of all the bodies of the universe can never stop it."

A new contribution to this inquiry was read recently before the American Philosophical Society by Mr. Luigi d'Auria. The object of the investigation was to determine whether, assuming the interstellar ether to possess the virtue of gravitational attraction, the force exerted by it would be sufficient to account for the proper motions of stars, and especially of the flying star 1830 Groombridge. In this paper it is shown that, "given the ether the density as estimated by Maxwell, and the power of attracting matter by gravity, a body placed within the sphere of ether containing all the stars of the visible universe, and at a distance from the centre of such sphere equal to that passed over by light in 2200 years, would pass this centre with a velocity equal to that of the star 1830 Groombridge, taking into account the attraction of the ether alone; and such body would oscillate about the same centre, rectilinearly, with a period of a little over *seven million* years, which would be also the period of oscillation of every other star." Mr. d'Auria recognises that some other, and unquestionable, cause may eventually prove to be responsible for stellar proper motions, nevertheless he thinks his results are worth putting on record.

NEW DETERMINATION OF THE SOLAR CONSTANT.—A fresh contribution to our knowledge respecting the sun's heat appears in the *Memorie della Società degli Spettroscopisti Italiani*, vol. xxvi., 1897, where Dr. G. B. Rizzo describes a series of observations for determining the solar constant, made at the station "Regina Margherita" on Monte Rosa. The apparatus used was a slight modification of Ångström and Chwolson's; the sun's rays being received on two brass discs attached to thermometers, which were alternately exposed and protected by two aluminium screens so arranged that when one disc was covered the other was exposed. To determine the quantity of solar heat absorbed per unit area per unit time, the formula of Chwolson was employed. Owing to the unsettled weather in September last, when the observations were made, the results were found at times to fluctuate considerably. In determining the solar constant or quantity of heat (measured in calories per minute) incident normally on a square centimetre at the earth's distance from the sun, it is necessary to assume some law for the effect of atmospheric absorption at the place of observation. Dr. Rizzo finds that the formulæ of Forbes and Crova for this purpose, when applied to his present observations, give for the solar constant the respective values 3·133 and 4·934. Both these values are somewhat in excess of the average of previous observations, but the divergence between them renders further investigation desirable.

THE DIAMETERS OF JUPITER AND HIS SATELLITES.—Herr Leo Brenner communicates to the *Astronomische Nachrichten* (No. 3444) the results of recent measures, made by him at the Manora Observatory, of the widths of the various bands and belts on Jupiter, and the angular diameters of the planet and its four large satellites. The following are the results of the measurements of diameters, reduced to mean distance:—

	Equatorial diameter.	Polar diameter.	Oblateness.
Jupiter	38″·539	36″·134	1 : 16·024
Satellite I.		1·060	
Satellite II. ...	1·063	0·958	1 : 10·123
Satellite III. ...	1·704	1·504	1 : 8·52
Satellite IV. ...	1·550	1·345	1 : 7·568

ACTION OF JUPITER AND SATURN UPON ENCKE'S COMET.—In a memoir which will shortly appear, M. A. Lebeuf gives formulæ for calculating secular inequalities when the mutual inclinations of orbits, and the eccentricity of the orbit of the disturbed body, are known. The formulæ are applied by M. Lebeuf, in the *Bulletin Astronomique*, to determine the secular inequalities of the elements of the orbit of Encke's comet in consequence of the action of Jupiter and Saturn. The values obtained are tabulated below:—

Elements of orbit.	Secular inequality due to Jupiter.	Secular inequality due to Saturn.	Simultaneous action of Jupiter and Saturn.
$\frac{de}{dt}$	+ 1″·38	+ 0″·2	+ 1″·40
$\frac{di}{dt}$	− 25·6	− 0·45	− 26·1
$\frac{d\Omega}{dt}$	− 35·9	− 0·85	− 36·8
$\frac{d\omega}{dt}$	+ 28·3	+ 0·66	+ 29·0
$\frac{d\epsilon}{dt}$	− 133·6	− 3·04	− 136·6

It is pointed out that the large eccentricity of Encke's comet, and the small distance of the comet from Jupiter, makes the use of the formulæ difficult in the case of Jupiter; but the results seem to justify their application to the case of Saturn.

PHASE-CHANGE OF LIGHT ON REFLECTION AT A SILVER SURFACE.

A LIGHT wave, when reflected[1] at the surface of separation of two media, may be altered in amplitude, or wave-length, or phase. Whilst, however, a change of amplitude or wave-length produces an obvious difference between the incident and reflected light, the existence and nature of a change of phase can only in general be inferred from the result of some kind of interference experiment. Thus the fact that a very thin transparent film is black when viewed by reflected light leads to the conclusion that a light wave is altered in phase by half a wave-length on reflection, either at a denser or at a rarer medium. Mechanical analogies suggest that the change probably takes place at the denser medium; and an experiment of Lloyd's, in which coloured fringes with a black centre were obtained by the interference of two beams of light, one directly transmitted, and the other reflected from a glass mirror, led to the same conclusion.

Jamin's experiments on metallic reflection showed that when light is reflected from a silver surface a phase-change is produced, and, moreover, that this change is different according as the light is polarised in, or perpendicular to, the plane of incidence. His experiments led to the determination of the

1 The term "reflection" is here used in its most general sense, to include such phenomena as phosphorescence, &c.

difference between the phase-changes in these two cases, but gave no direct information as to the absolute magnitude of either.

By depositing a wedge-shaped silver film on the outside of one of the thick glass mirrors of a Jamin refractometer, and observing the interference bands where they crossed from the glass-air to the glass-silver surface, Quincke concluded that the phase-change, when light is reflected in glass from a silver surface, depends on the thickness of the silver, but was unable to decide whether it was a quarter-wave acceleration or three-quarters of a wave retardation for a thick silver film. The reason of his uncertainty will be explained later. Wernicke and Wiener analysed spectroscopically the light reflected from thin transparent plates, the back surfaces of which were partly silvered. The spectra obtained were crossed with black bands, depending in number and breadth on the thickness of the plate; and these bands were displaced where the light was reflected from the silver surface. Wernicke, however, concluded that the phase-change amounted to a quarter-wave acceleration, whilst Wiener concluded that it was of the nature of a retardation of three-quarters of a wave-length. Wernicke has since stated that silver films could be obtained which would produce either of these phase-changes, according to the nature of the film.

A modification of Michelson's refractometer may be advantageously used to study this vexed question. Light from a lamp L, placed at the principal focus of a lens M, falls on the thinly-silvered mirror A, part being reflected along the path

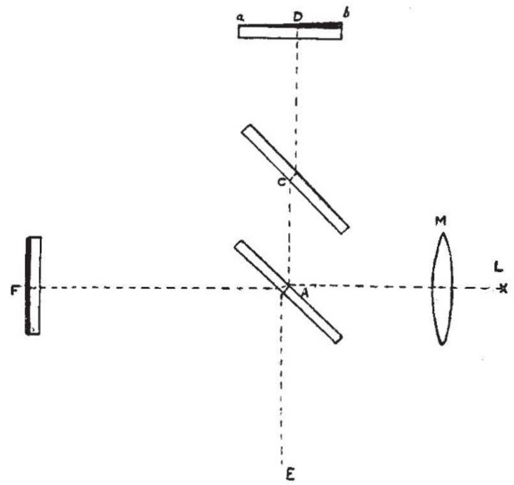

FIG. 1.

A C D, and after reflection from the back surface of D, pursuing the path D C A E, to the eye of the observer. The light originally transmitted through the mirror A pursues the path A F A E. If the two paths are equalised, brilliant interference bands are produced.[2] It will be noticed that these bands are virtually formed by the reflection of light at an air film, comprised between D and the image of F in A. Consequently both they and the surface of D can generally be focussed simultaneously.

Both D and F are silvered on their back surfaces; the film on F is uniform, whilst that on D increases in thickness from one side to the other, as indicated (with exaggeration) by the black line *a b* (Fig. 1). A horizontal strip of glass is also left unsilvered across the middle of D.

The method of obtaining the silver wedge was as follows. The glass was first well cleaned with strong nitric acid, using a small mop made of cotton wool plugged into the end of a glass tube. An ordinary elastic band was then stretched round the plate, and the whole was placed, inclined at an angle of about 30°, in a beaker, and distilled water poured in till it reached the height of the top of the glass plate. A glass syphon tube, reaching to the bottom of the beaker, was introduced, the flow being capable of regulation by a stop-cock on the outer limb. Silvering solution was then quickly poured in through a funnel reaching to the bottom of the beaker. The water was simply displaced upwards, and a few minutes after the silvering solution had reached the level of the top of the plate the stop-cock of the syphon was cautiously opened, so as to slowly withdraw the silvering solution. The flow should at first be moderately quick, but should decrease later. Silver films will be found deposited on both sides of the glass, that on the under side being the better; the film deposited downwards is generally very milky in appearance, and is frequently spotted. If the glass is not washed with nitric acid after the elastic band is placed round it, the silver will be found to gradually shade off towards the clear glass.

The following silvering solution may prove useful to those who wish to make half-silvered mirrors; it was used to form the silver wedges on account of the slowness of its action.

Take silver nitrate 1 gr., dissolved in 20 c.c. of distilled water. Add strong ammonia (·88), drop by drop, till the precipitate formed is just re-dissolved. Add a solution of 1·5 gr. caustic potash (ordinary stick potash works well), dissolved in 40 c.c. of water; then ammonia, drop by drop, till precipitate is just re-dissolved. Add 80 c.c. distilled water, and then a solution of silver nitrate (strength unimportant), till a permanent precipitate is just formed. Make the solution up to 300 c.c. 1·8 grs. milk sugar are dissolved with heating in 20 c.c. distilled water. This solution is added to the above just before silvering is to commence; after a few minutes the whole will commence to

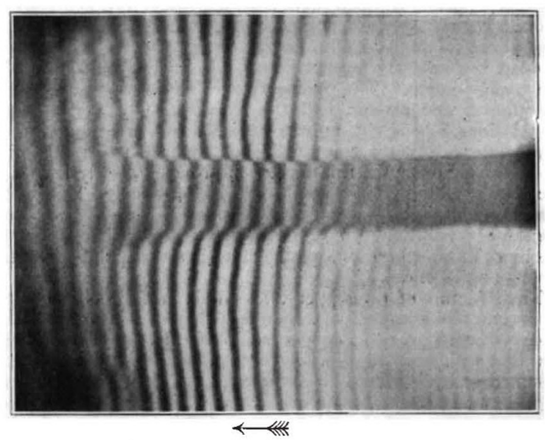

FIG. 2.—The thin edge of the wedge is to the left. A displacement of the bands in the direction of the arrow is produced by lengthening the path A C D (Fig. 1).

blacken. The glass to be silvered may be placed horizontally in an ordinary evaporating basin, and the solution poured in till it reaches the upper surface of the glass. The silver is deposited upwards. For half-silvering about ten minutes is required, when the temperature is about 15° C. For thick silvering the plate should be left at least an hour; we have frequently left it all night with good results. The thick silver film produced may be scrubbed with cotton wool under running water, and finally left for some time in distilled water, when it may be removed and left to dry.

The above recipe for silvering was given to us some years ago by Prof. Boys. It was originally due, we believe, to Prof. Liveing.

Fig. 2 is taken from a photograph of the bands produced, using yellow light (the light from an electric arc passed through a cell, made of signal green glass, filled with a saturated solution of bichromate of potash) and a Cadett plate; exposure, one minute.

The dark band across the figure represents the strip of clear glass on which silver was not deposited. The bands, in passing from the glass-air to the glass-silver surface are seen to be displaced towards the thin edge of the wedge-shaped film, and it is at once seen that the displacement depends on the thickness of the film. In order to produce a displacement of the bands in the same direction, the length of the path A D must be increased. This, according to Wiener, would indicate that the light was retarded on reflection from thick silver by three-quarters of a wave-length. It will be noticed that the bands are continuous, passing from the glass-air to the glass-silver surface. This is

[2] For a simple method of constructing this apparatus, see NATURE, August 17, 1893, "Apparatus illustrating Michelson's method of obtaining interference bands." Following Michelson, it was there stated that the central band is always black. We have since determined that the colour of the central band will vary according to the phase-changes produced at the various silver surfaces. We have been able to obtain a white central band.

due to the fact that the silver gradually shades off towards the clear glass. Occasionally, however, each band, in passing from the glass-air to the glass-silver surface, is joined to *both* the nearest bands on the silver. It was due to this cause that Quincke was unable to say whether an acceleration or retardation was produced.

Wernicke states that a retardation is only produced when the silver is of a friable nature, and could be readily rubbed off the glass. The accompanying photograph was obtained with a silver film that easily bore polishing, and showed no want of adherence to the glass.

E. EDSER.
H. STANSFIELD.

MICRO-STRUCTURE OF ALLOYS.

AT the Royal Society's conversazione this year, Mr. J. E. Stead exhibited a series of photographs illustrating the micro-structure of various alloys. In many cases the structure portrayed was very complex and interesting, and in some cases beautiful.

Many series were illustrated by Mr. Stead, but it would take much more space than is available in a short notice to more than point out briefly the main features of a few.

The photographs showed that when the antimony exceeded 7·5 per cent. in antimony-tin alloys, the excess over that amount separated out with an equal atomic proportion of tin as more or less perfectly formed cubes. That they were crystals of definite chemical atomic composition Mr. Stead had verified by several careful analyses after having dissolved away the eutectic, or what was once the mother liquor, with nitric acid, which left the crystals intact. The photographs of alloys of tin containing phosphorus and arsenic had the appearance of very straight bright lines, which cut up the surface into irregular figures. These lines are the edges of flat plates, which, when separated by dissolving away the tin, have been proved by analysis to have the composition of Sn_3P_2 and Sn_3As_2, respectively. The photographs of the separated compounds indicate that they had both the same crystalline form of hexagonal plates. A photograph of one of the free ends of a plate showed several pointed crystals having angles of 60°.

The structure of tin-copper alloys rich in tin was illustrated by several photographs, which showed that in alloys containing from 2 to 0·10 per cent. copper acicular crystals were present, and that with each addition of copper the separated compound assumed a more plate-like structure, until when 35 per cent. copper was present, apparently it was all in the form of plates. All these compounds have been separated and analysed by Mr. Stead, with the following results :—

Alloy.		Crystals separated. Copper.	Tin.	
98·0 °/₀ tin, 2·0 °/₀ copper	...	34·58 °/₀	65·42 °/₀	SnCu (approximate.)
97·0 ,, 3·0 ,,	...	36·50 ,,	63·50 ,,	
95·0 ,, 5·0 ,,	...	39·80 ,,	60·20 ,,	
90·0 ,, 10·0 ,,	...	44·60 ,,	55·40 ,,	Sn_2Cu_3 ,,
85·0 ,, 15·0 ,,	...	47·20 ,,	52·80 ,,	
80·0 ,, 20·0 ,,	...	53·00 ,,	47·00 ,,	
65·3 ,, 34·7 ,,	...	56·12 ,,	43·88 ,,	$SnCu_2$,,

It will be seen that although the compound separated from the 2 per cent. alloys approximates to the composition of SnCu, each addition of copper to the alloy results in the formation of a compound which after separation proves to contain a greater proportion of copper than that from the alloy containing less copper.

It has not yet been proved whether these compounds are amorphous mixtures or combinations of one or more atomic chemical constituents.

It appears that in all the solid alloys of lead and antimony the elements are in a free state. There is a eutectic which contains 12·7 per cent. antimony. Those having more than that quantity of antimony contain large crystals of free antimony, which until 50 per cent. is present are found at the upper part of the alloy if the cooling of the liquid alloy has been sufficiently slow, but between these crystals the eutectic is clearly visible. When the antimony is increased to 50 per cent. the white crystals and dark eutectic occupy nearly equal areas, and with each addition of antimony the dark areas diminish until when 100 per cent. is present the surface presents a homogeneous white appearance free from the dark eutectic.

With alloys containing less than 12·7 per cent. antimony the polished and etched surfaces clearly show the presence of dendritic crystals of lead.

The eutectic has the very peculiar structure similar to that of nodular radiated pyrites. On treating this compound with dilute nitric acid for a long period, a coherent dark-coloured mass is left free from lead, and which appears to consist when broken up as very fine bright plates, exceedingly thin and easily broken up, with the slightest pressure, into what appears to be an amorphous powder.

FIG. 1.—× 30.
Sn, 75 per cent. ; Sb, 20 per cent. ; As, 5 per cent.

Mr. Stead and Mr. Charpy have simultaneously investigated the alloys of tin-antimony, tin-copper, and lead-antimony, and the results of their micro-examinations are almost identical; but Mr. Stead has supplemented his micro-research with chemical examination, which greatly increases their value.

The micro-structures of ternary alloys are of very much greater interest than those of two metals only, for Mr. Stead

FIG. 2.—Magnolia metal. Magnified 200 diameters.
Pb, 80 per cent. ; Sb, 15 per cent. ; Sn, 5 per cent.

has shown that it is possible to detect two, and sometime three, distinctly different compounds in the same microscopic field. Sometimes two of the elements combine and crystallise together ; sometimes three will so unite. Examples of tin-copper-antimony, and tin-antimony-arsenic (Fig. 1), and lead-antimony-tin (Fig. 2), and tin-antimony-phosphorus were shown at the Royal Society.