understanding of various aspects of animal life. Yet the living creature is fundamentally a unity. In trying to make the "how" of an animal existence intelligible to our imperfect knowledge we have, for purposes of study, to separate its whole into part-aspects and part-mechanisms, but that separation is artificial. It is as a whole, a single entity, that the animal, or for that matter the plant, has finally and essentially to be envisaged. We cannot really understand one part without the other. Can we suppose a unified entity which is part mechanism and part not? One privilege open to the human intellect is to attempt to comprehend, not leaving out of account any of its properties, the "how" of the living creature as a whole. The problem is ambitious, but its importance and its reward are all the greater if we seize and attempt the full width of its scope. In the biological synthesis of the individual it is concerned with mind. It includes examination of man himself as acting under a biological trend and process which is combining individuals into a multi-individual organisation, a social organism surely new in the history of the world. This biological trend and process is constructing a social organism the cohesion of which depends mainly on a property developed so specifically in man as to be, broadly speaking, his alone, namely, a mind actuated by instincts but instrumented with reason. Man, often Nature's rebel, as Sir Ray Lankester has luminously said, can, viewing this great supra-individual process, shape his course conformably with it even as an individual, feeling that in this case to rebel would be to sink lower rather than to continue his own evolution upward.

Scientific Problems and Progress.

ADDRESSES OF PRESIDENTS OF SECTIONS OF THE BRITISH ASSOCIATION.

THE THEORY OF NUMBERS.

IN his presidential address to Section A (Mathematics and Physics), Prof. G. H. Hardy propounded a series of five problems of general interest in the theory of numbers, which are still awaiting solution.

(*a*) *When is a number the sum of two cubes, and what is the number of its representations?* The density of the distribution of such numbers tends to zero as the number tends to infinity, but no simple criterion by which these numbers can be recognised is known. The least number expressible in more than one way as a sum of two cubes is 1729, which is 12^3+1^3 or 10^3+9^3. Four representations of 19×363510^3 are known, and this is apparently the largest number of such forms which has been obtained.

(*b*) *Is every large number the sum of five cubes?* Two numbers, 23 and 239, require nine cubes; there are fifteen numbers requiring eight, and 121 numbers requiring seven, the largest of the latter being 8042. Six-cube numbers probably disappear before reaching 1,000,000, and possibly five-cube numbers also disappear, but in huge numbers, for four-cube numbers persist for ever.

(*c*) *Is $2^{137}-1$ prime?* This problem belongs to the theory of the so-called "perfect" numbers, each of which is the sum of all its divisors including unity. The number 2^n-1 can be prime only when n is prime, and 137 is the least value of n for which the answer is still doubtful. Two other problems connected with the perfect numbers, for which solutions are still sought are: Can a perfect number be odd? and, are there an infinite number of perfect numbers?

(*d*) *Are there infinitely many primes of the form n^2+1?* The general distribution of primes is, in all essentials, solved, but much remains to be done among numbers of special form. The form n^2+1 is the simplest case of the general form $an^2+2bn+c$, and although an approximate formula, which has been well tested, has been obtained for determining the number of primes, there is no immediate prospect of an accurate proof.

(*e*) *Are there infinitely many prime pairs, p, $p+2$?* This is a particular case of the question whether any group of primes recur indefinitely. Apparently all possible groups recur for ever with definite frequency, and so far as the first million numbers are concerned, the proposition has been tested, but there is no rigid proof of its accuracy.

CHEMISTRY OF THE SUGARS.

PRINCIPAL IRVINE spent the first part of his address to Section B (Chemistry) in discussing the new responsibilities which devolve upon scientific chemists who take advantage of the facilities offered by the Department of Scientific and Industrial Research (see NATURE, July 22, p. 131).

The second section of the address was devoted to an account of how investigations on the sugars carried out in the St. Andrews' Laboratories for many years are being developed so as to include the structural problems of the polysaccharides. These compounds are shown to be composed of comparatively simple units, as indicated below.

Cellulose.—α-Cellulose gives a trimethyl derivative as the maximum substitution product, and this in turn yields on hydrolysis only 2-, 3-, 6-trimethyl glucose. The simplest formula for cellulose would thus be an anhydro-di-glucose, each hexose residue being substituted in positions 1 and 5, but, in order to accommodate the yield of cellobiose obtained from cellulose, the molecule for the latter is held to be that of a tri-(1-, 5-anhydroglucose).

Starch.—The methylation of starch gives a product which contains seven methyl groups for every unit of eighteen carbon atoms. These are distributed in such a manner that one glucose residue contains three methyl groups, while two such groups are present in each of the remaining glucose residues. Starch is thus based on an anhydro-trisaccharide to which a structure has been ascribed.

Inulin.—This polysaccharide is known to be composed entirely of γ-fructose residues, and each of these has now been shown to be identical in structure. It is in the meantime premature to say if inulin is derived from the simple unit $C_6H_{10}O_5$ or from the double or triple multiple of this, but in any event the γ-ketose residues are symmetrically disposed.

A close structural relationship has thus been established between (*a*) cellulose and starch, (*b*) starch and lactose, (*c*) inulin and sucrose.

PHYSIOGRAPHY OF THE COAL SWAMPS.

THE purport of the presidential address delivered by Prof. P. F. Kendall to Section C (Geology) was to show that coal seams are the result of growth and accumulations of peat, *in situ*, and that all the phenomena of the British coal-measures can be explained upon this hypothesis, with the necessary implication of great deltaic swamps.

The English coal-measures consist of fresh-water muds and sands with occasional intercalations of marine sediments of relatively small amount. This theory is in full accord with what is known of modern swamps and deltas. Two types of sandstones occur; one, having the form and arrangement of deltaic sand-banks, is often of wide extent, the other taking the form of meandering river-channels which may cut out an entire seam, producing a "wash out." One such example, in which 90 ft. of normal measures and large areas of coal are replaced, was mentioned.

The splitting of coal-seams is attributed in some cases to contemporary river-erosion, and in others to local sags, drowning the vegetation and interrupting coal growth. Effects of contemporary earthquakes are recognisable in many seams and districts. They take the form of "lurched" margins of wash-outs, casts of sand-fountains, sandstone dykes, "swillies," or trough-like inflexions of seams, and contemporary faults affecting lower and not upper seams. All these effects are of earlier date than the ordinary faulting of the strata.

In discussing the various types of material which constitute coal-seams, stress was laid on the distinction between coal and cannel. The explanation of "coal balls" proposed by Stopes and Watson is accepted with the corollary that the constituent plants must, in some cases, have grown in salt water.

In conclusion attention is directed to the phenomenon of cleat, that is, the system of jointing in coal, the one coal-measure phenomena for which there is no obvious modern parallel. Observation of its direction all over the world and in deposits of all ages, from Carboniferous to Pleistocene, shows an overwhelming preponderance of N.W.-S.E. in the northern hemisphere and N.E.-S.W. in the southern. This seems to be in some way related to the earth's planetary rôle, but data are not yet sufficiently complete to justify the formulation of a theory. Every morsel of coal, even a single leaf of cordaites $\frac{1}{100}$ of an inch in thickness, exhibits a regular cleat in the specified direction. The absence of cleat in anthracite is held to explain the low ash percentage. Jointing, comparable to cleat and agreeing in direction, occurs in some limestones.

THE PROGRESSION OF LIFE IN THE SEA.

IN his address to Section D (Zoology) the president, Dr. E. J. Allen, first discussed the theory that life in the world had its origin in the sea, referring to recent work by Baly on the formation of formaldehyde and sugars by the action of light of short wave-length on carbonic acid and water, and to the views expressed by Church on the building up of an autotrophic flagellate from the ions present in sea-water. An account was given of work on the culture of marine diatoms, showing the necessity for the presence of traces of organic matter before healthy growth of plant life took place. The passage from plant to animal nutrition was illustrated by the chrysomonad Pedinella. A similar change in nutrition was described amongst the Dinoflagellates. The line of progression from the flagellates to the metazoa probably proceeded through the cœlenterates, which represent the highest stage attained by the primary plankton or free-swimming animals. Further development took place when the latter established a connexion with the sea-bottom. Many of the bottom-living animals subsequently again adopted the free-swimming habit, and gave rise to the various groups of animals found in the plankton to-day. Fishes were probably evolved in rivers, and developed their swimming powers to resist the action of the current.

The conditions controlling the production of organic food material in the sea were discussed and some account given of the food-chain from the diatom and peridinian to the fish. Recent work by Hjort and Drummond was described, on the production of vitamin by marine plankton diatoms, and the passage of this growth stimulant through their food into the bodies of fishes, where it is found in the oil of the liver and subsequently in the ovary. In conclusion it was urged that for the solution of problems dealing with practical fisheries the life of the sea must be studied as a whole.

HUMAN GEOGRAPHY.

DR. MARION NEWBIGIN'S address to Section E (Geography) was on "Human Geography: First Principles and Some Applications." Geographers are agreed that there is a definite human geography, but little attention has been given to the problem as to the precise way in which man's response to environmental conditions differs from that of animals. Since man once ran into a number of species—or even of genera—it is obvious that there was once a time when there was no distinctively human response, when adaptation led to specific differentiation, just as it does among animals. But since all living men now belong to one species, it is clear that this time has passed. Its passing appears to be associated with the fact that growing intelligence meant that the barriers to distribution which limit the movements of animals ceased to function. This in its turn might have meant that human evolution stopped, that man ceased to be adapted to any particular habitat because fitted for all, were it not that the factors of fixation and isolation, so important in the case of the lower organisms, began to act in a new way. With the growth of cultivation, communities became fixed to particular areas, and if the isolation was sufficient to ensure the necessary continuity and protection during the early stages, a communal as distinct from an individual adaptation appeared. The second part of the address dealt with applications of these general principles to the chief foci of civilisation in Europe and the adjacent lands. Thus the causes which promoted the origin, growth, and decay or modification of the successive cultures of the great river valleys, of the Mediterranean seaboard, and of the forest belt of Western Europe were considered, and the peculiar difficulties encountered in establishing stable communities in the steppe lands of Eastern Europe discussed briefly.

Railway Problems of Australia.

The presidential address to Section G (Engineering), by Prof. T. Hudson Beare, was on "Railway Problems in Australia." Two great problems have to be faced by the Commonwealth—(1) the unification of the existing railway gauges, and (2) the joining up of the tropical areas of Northern Australia by a system of railways linking up with the railway systems of the southern and eastern areas of the continent.

(1) The first is a problem which has been prominent since 1888; up to the present no satisfactory solution has been found. Various Royal Commissions have inquired into the matter, and the only point which has been definitely settled is that the standard gauge shall be 4 ft. 8½ in. In 1921 a Royal Commission made two proposals—(1) to convert the main railway system connecting the various capitals from Fremantle to Brisbane to a uniform 4 ft. 8½ in. gauge, the length of track being somewhere about 3300 miles, the estimated cost of conversion and of the necessary new lines being 19,000,000*l.*, which would be increased to a total of 21,500,000*l.* if all the 5 ft. 3 in. lines in Victoria and South Australia were simultaneously converted to 4 ft. 8½ in.; (2) to convert the whole Australian railway system to 4 ft. 8½ in.—this the Commission estimated would cost about 57,000,000*l.*, but this estimate has not been accepted by the State railway authorities, and the Premier of South Australia at a recent conference stated that he was of opinion that the total cost would not be far short of 100,000,000*l.* sterling. If some mechanical device for overcoming the break-of-gauge difficulties could be evolved, the need for the expenditure of this enormous sum would be postponed to a period when it is to be hoped costs of constructional work would be greatly reduced.

(2) When the Commonwealth took over the Northern Territory from the State of South Australia on January 1, 1911, an agreement was entered into between the Commonwealth and the South Australian Government to the effect that the Commonwealth Government should construct a north-south railway connecting Port Darwin with Adelaide. It was agreed to construct a railway line from a point on the Port Darwin and Pine Creek railway southwards to a point on the northern boundary of South Australia proper, and a railway northward from a point on the Port Augusta and Oodnadatta railway to connect with the other portion of the line at a point on the northern boundary of South Australia proper. Up to the present no definite steps have been taken to carry out this agreement, but the Commonwealth Joint Standing Committee of Public Works last year appointed a sub-committee to investigate the country of this route and to take evidence. The Commonwealth Engineer for Ways and Works submitted two alternative transcontinental routes: (*a*) a direct north-south line with the necessary branches to connect it with the Queensland railways, estimated cost about 16,000,000*l.*, and (*b*) the eastern route, estimated cost about 14,300,000*l.*, to which must be added an additional sum of about 1,500,000*l.* if the existing 3 ft. 6 in. line from Port Augusta to Oodnadatta was extended to Alice Springs in order to open up the McDonnel Range country for closer settlement. The urgency for a prompt decision in regard to the route of the north-south line is brought out by the fact that at the present time the journey by sea from Brisbane, the nearest State capital, to Darwin takes longer than the sea voyage from Darwin to Singapore or Hong-Kong, a perilous state of things to the Commonwealth in certain contingencies which need not be more emphasised but are obvious to all who are fighting so strongly for the white Australia policy.

The Study of Man.

In his presidential address to Section H (Anthropology) Mr. Harold Peake said that during the last twelve years an anthropological school has arisen, which regards different groups of men as following, not one single path of evolution, but various routes according to their environment. This view has brought the anthropologist more closely into touch with the geographer, who has thereby become more human and less factual, has interested the sociologist and the economist, has infected many classical scholars, and may even wean the historian from a too exclusive study of kings and politicians. Anthropology may be defined as "the study of the origin and evolution of man and his works." As such it must be psychological as well as physical, dynamic rather than static. Nor must it be limited to the study of backward peoples, but extended to such civilised peoples as those of the Far East and Hindustan. We have much information concerning the arts, languages, and official religions of these regions; too little concerning the physical and mental traits of their "masses," their customs and actual beliefs. Such ignorance leads to constant misunderstanding and friction, as, for example, in India, and this can be removed only by giving our rulers there some training in anthropology. The British Schools at Rome and Athens have been of enormous value in establishing friendly relations. Let there be a British School in India, endowed by private benefactors of both races, to act as an anthropological centre from which would radiate a truer understanding of the ideals of both civilisations. The need for similar institutions in the European region is painfully manifest. It is, in fact, the spirit if not the detailed facts of anthropology which seem most likely to lead to that breadth of view and deeper sympathy which humanity requires. We need this not abroad alone; we have in these islands, as the result of successive invasions, various races, each with peculiarities of outlook which still lead to friction. These the anthropologist must study for the sake, not of knowledge only, but also for the sake of peace.

The Efficiency of Man and the Factors which influence it.

In his presidential address to Section I (Physiology) Prof. Cathcart, after a brief discussion of the meaning of the term efficiency, in which he differentiated mechanical and industrial efficiency, went on to emphasise the intimate relation which exists between the efficiency of man in the physiological and industrial sense. There was a tendency to lay too much stress on organisation and machinery; to forget the fact that no matter what mechanical improvements were evolved man was always behind the machine, and that, therefore, physiological laws must be reckoned with as an essential factor in industrialism. Attention was directed to the tremendous annual loss in time due to sickness and disability, and it was pointed out that primarily this wastage could not be charged to man being of unsuitable design for the work he was called upon to perform; on the contrary, the physiological balance of the organism was beautifully designed to meet most varying strains. After reference to the relation of the various systems, respiratory, circulatory, etc., to the maintenance of efficiency, Prof. Cathcart went on to discuss the factors which, in his opinion, play the predominant rôles in the maintenance of maximum efficiency. He believed that there were, at least, four intrinsic factors, *i.e.* factors directly related to muscle movement—(*a*) the rate of the performance of the work, (*b*) the amount of rest offered to or taken by the subject, (*c*) the rhythm with which the work was performed, and (*d*) the work habits developed by the worker. He reviewed each of these factors in turn; the influence of load and the type of work (positive and static) was dealt with under the rate of performance, and the formation of conditioned reflexes in connexion with rhythm and habit. The more extrinsic factors, *i.e.* those less directly related to muscle effort, were next discussed, including the influence of the state of nutrition and the nature of the food supplied, of the work environment, and the psychic factor generally, particular reference being made to monotony of occupation and the part played by the temperament of the worker. Other still more extrinsic factors like housing, personal habits, lighting, heating, ventilation, etc., were also mentioned. The general conclusion reached was that although the real over-all efficiency of the worker could not be causally related to any single factor, further scientific investigation along physiological lines, with the mutual co-operation of the employer, employee, and scientific worker, would throw much light on this most difficult and vitally important problem.

Transport of Organic Substances in Plants.

The address to Section K (Botany), by Prof. H. H. Dixon, dealt with the transport of organic substances in plants. Organic substances are conveyed upwards in the rising transpiration and root-pressure currents. The transport is probably mainly effected in the tracheæ of the outer layers of the wood. Ringing may block these channels completely or partially by the introduction of air-bubbles and by exudations from injured cells into the lumina and walls of the tracheæ.

The downward transport of these substances from the leaves to the lower parts of the plant is usually assigned to the bast, although there is weighty experimental evidence that living conduits are not essential. Calculation shows that if the bast were used as the conduit a velocity of flow in it of about 50 cm. per hour would be required. In such narrow tubes as the bast is composed of, with frequent cross partitions and colloid contents, this velocity seems quite impossible. These considerations render it highly probable that the tracheæ of the wood are the path for downward transport also. There is ample experimental evidence for downward as well as upward movement of sap in the tracheæ. Tension in the sap determines a flow from any source above or below. Resistance to transverse flow in the wood practically subdivides that tissue into a number of longitudinal filaments of tracheæ connected anatomically at various levels in the plant. Transpiration from the upper end of one filament may thus lead to a downward motion in a neighbouring one.

There is also conclusive evidence for this reversed motion in intact normal plants.

Recent work has shown that the transfer of stimuli from the receptive to the motile regions of plants is effected by the passage of hormones. In several cases it is certain that the hormones are conveyed in the transpiration current. Moreover, the movement is often basipetal. Such a downward flow is clearly available for the conveyance of organic foodstuffs as well as hormones. Local increases in the permeability of leaf-cells will allow solutions of organic substances to pass into the tracheæ. The tension generated in the sap by the transpiration of other leaf-cells will draw this solution downwards in the tracheæ. Experimental evidence for this method of transport is available. The volume-changes of leaves and parts of leaves observed during transpiration are in all probability the result of these changes in permeability, and are directly connected with the supply of organic substance from the leaf-cells to the transpiration-current for downward transport.

Educational and School Science.

Sir Richard Gregory's address as president of Section L (Educational Science) was a statement of the biological basis of education and a plea for broader conceptions of the scope and substance of science teaching in schools. It is the business of education to promote the right adjustment between the developing human organism and its surroundings, and this implies that the nourishment provided at all stages of growth should be not only such as supplies the needs of the moment but also builds up strength to live a full life under the conditions of the times. School instruction in science is not, therefore, intended to prepare for vocations, but to equip pupils for life as it is and as it soon may be. It is as essential for intelligent general reading as it is for everyday practical needs; no education can be complete or liberal without some knowledge of its aims, methods, and results, and no pupil in primary or secondary schools should be deprived of the stimulating lessons it affords. In such schools, however, the science to be taught should be science for all, and not for embryonic engineers, chemists, or even biologists; it should be science as part of a general education—unspecialised, therefore, and without reference to prospective occupation or profession, or direct connexion with possible university courses to follow. There is very present need for the reminder that science is not all measurement, nor is all measurement science. In the great majority of secondary schools science signifies chiefly quantitative work in physics and chemistry—laboratory exercises and lessons based upon them—and rarely is any attempt made to show the pupils what a wonderful world we live in, or what science has done, and is doing, for them in everyday life. By the prevailing obsession in regard to quantitative work the pupil is made the slave of the machine, and appliances have become encumbrances to the development of the human spirit. In addition to subjects studied experimentally, there should be general science courses covering a wide field. Geography can be made the unifying principle of such instruction. Practically all the subjects of a broad course of general science are of geographical significance, inasmuch as they are concerned with the earth as man's dwelling-place, and are the scene of his activities.

The Royal Observatory, Greenwich.

THE Royal Observatory is situated in Greenwich Park on the edge of a scarp overlooking the Thames. The ground descends sharply to the north and west. On the east (running diagonally across the photograph) is a level avenue leading southwards to Blackheath. This is joined at an acute angle a little south of the observatory by the avenue from Greenwich, which rises at moderate gradient to the level of the plateau.

The observatory was founded by Charles II. and designed by Wren. The original building, A, is shown surmounted by the time-ball at the north-east corner and anemometers on the north-west and south. The octagon room, so called from its shape, contained in this building was the observatory of Flamsteed, who was commissioned to make observations of the sun, moon, and planets for the assistance of navigators, especially with the view of their utilising predicted positions of the moon among the stars for the determination of longitude at sea. Some of the instruments employed by Flamsteed were in this room, but others were in the open. Under the octagon room are four small rooms where Flamsteed lived. In Maskelyne's and Airy's time additions were made to the house by buildings to the south and west; the part of the Astronomer Royal's official residence looking over the western edge of the scarp is shown prominently in the picture.

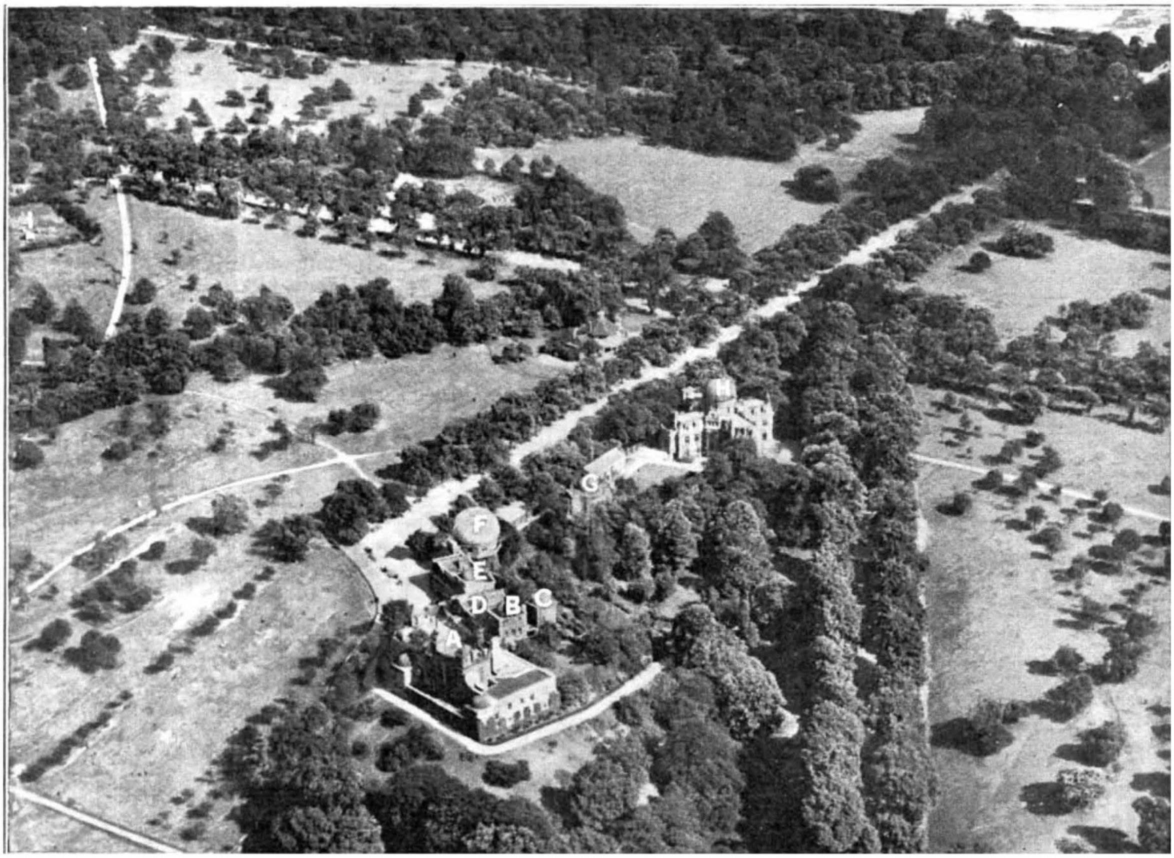

Photo by Central Aerophoto Co., Ltd.

THE ROYAL OBSERVATORY, GREENWICH.

A=ORIGINAL BUILDING. B=ASTROGRAPHIC EQUATORIAL. C=PHOTO HELIOGRAPH. D=TRANSIT CIRCLE. E=SHEEPSHANKS TELESCOPE. F=28-INCH EQUATORIAL. G=ALTAZIMUTH. H=THOMPSON EQUATORIAL. I=MAGNETIC AND METEOROLOGICAL INSTRUMENTS.

To the south of the octagon room are shown two small domes. The first of them, B, covers the astrographic equatorial, a photographic telescope which was erected by Sir William Christie, and has done good service in the photographic mapping of the heavens, the determination of the solar parallax from observa-