

Astronomers Study Earth Motion at Stresa Symposium

Where is the north pole? How fast are the continents drifting? In the well known Chandlerian motion, the intersection of the instantaneous axis of the earth's rotation with the surface describes a rough circle. The radius is about 10 meters, corresponding to 0.35 sec of arc. The revolution, about a point called the "mean pole," takes about 14 months. There are variations in period and amplitude.

In 1899 the International Latitude Service was established to determine polar motion from latitude observations only. It has five stations, all near 39°8' north latitude, which observe the same stars each night. Their longitudes are as follows: Mizusawa, -141°; Kitab, -67°; Carloforte, -8°; Gaithersburgh, +77° and Ukiah, +123°.

B. Wanach analyzed the observations for the first 15 years and found that the mean pole was apparently moving secularly at 0.003 sec of arc per year toward +55° longitude. Although observations in later years generally confirmed the motion, whether it was real or caused by latitude changes of the individual stations from crustal drift has been controversial.

A symposium at Stresa, Italy, last March provided opportunity to discuss this problem, other aspects of motion of the pole, continental drift and earth rotation. Under sponsorship of the International Astronomical Union and the International Union of Geodesy and Geophysics, 49 scientists from 14 countries attended. The main purposes were to organize astronomical programs on continental drift and select an origin for computation of the location of the earth's pole of rotation.

Continental drift. In an invited paper George D. Garland (Toronto) estimated continental drift rates based on coastline matching, dispersal of areas having similar climatic histories and paleomagnetic measurements. The first two methods suggest an average separation rate between South America and Africa of 2 cm/yr during the past 280 million years. The magnetic measurements, coupled with the assumption that large-scale polar wan-

dering has occurred, give 0-12 cm/yr. Estimates based on ocean-floor magnetism indicate symmetrical flow patterns on both sides of the Pacific-Antarctic ridge.

ILS observations for 67 years were analyzed by William Markowitz (Marquette). He found in 1960 that in addition to a progressive motion, the mean pole undergoes a libration with a 24-year period so that the motion is zigzag. The motion for 1960.0 to 1966.0 agreed with that previously found. The 24-year term is puzzling; it is purely empirical. Markowitz concludes that the progressive and librational motions of the pole are real. He finds, however, that within the errors of observation, astronomical data fail to indicate crustal displacement. He stresses the need for higher accuracy in relative longitude measurements, which can be obtained by concurrent observations of the same stars.

Shigeru Yumi (Mizusawa Observatory) also discussed ILS results. His interpretation (with Yasujiro Wako) was that the observed polar motion was due to a southward crustal drift of Mizusawa, a northward crustal drift of Ukiah and a secular motion of the pole. In the discussion Markowitz pointed out that the very close agreement in phase of the variations in latitude at the stations could be explained by a single cause, such as an oscillation of the mean pole, but not by independent crustal oscillations.

Masahisa Torao, S. Okazaki and S. Fujii (Tokyo Observatory) reported

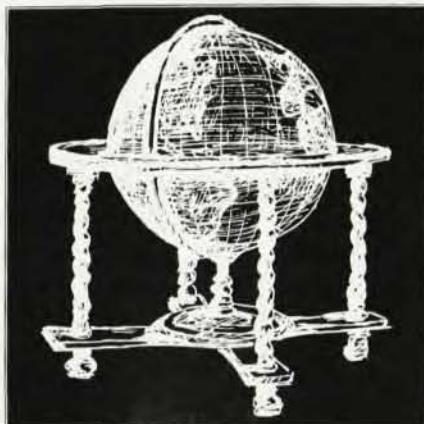
on variations in relative longitudes for various combinations of observatories from 1933 to 1962. It is hard to prove, they find, that these variations are literally due to continental drift; external systematic errors are large. Nicolas Stoyko obtained variations over a longer interval, but the data he used were very inhomogeneous.

Some meeting participants felt that relative drifts between continents of 1 to 5 cm/yr might be occurring. Some 30 to 50 years might be required to detect such drift by classical astronomical methods. If, however, a laser method proposed at the symposium is successful, such drifts, if they exist, may be detected in about 10 years.

Polar motion. Bernard Guinot (Observatoire de Paris) emphasized the usefulness of deriving polar motion by combining time and latitude observations and described methods of calculation. He compared the accuracies of the photographic zenith tube (PZT), the Danjon astrolabe, and other instruments. Sigetugu Takagi (Mizusawa Observatory) reported on the polar motion obtained from observations for time made at eight observatories. During the symposium co-operative programs of astronomical observations by several chains of two or more PZT's and astrolabes in the northern and southern hemispheres were established.

A. R. Robbins and Guy Bomford (Oxford University), in describing the need in geodesy for a fixed origin in computing the coördinates of the instantaneous pole, said that changes in origin have been made in the past and that various ones are now in use. The symposium recommended that the mean pole of 1903.0 be used as a common origin in astronomy and geodesy. This origin is based on ILS observations from 1900.0 to 1906.0.

Other geophysics. Paul J. Melchior (Observatoire Royal de Belgique) discussed body tides (flexures of the "solid" earth in response to tide-generating forces) as they affect rotation, precession and nutation of the earth. Results from horizontal quartz pendulums appear to require corrected am-



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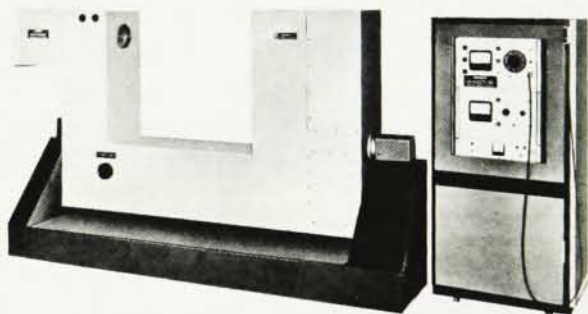
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plitudes for short-period nutations. S. Keith Runcorn (U. of Newcastle) attempted to relate continental drift and variations in speed of the earth's rotation.

During a lively discussion of satellites and their possible contributions to problems of measurement of intercontinental distances, Carroll O. Alley (Maryland) and Peter Bender (Colorado) proposed an experiment with a corner reflector on the moon. A laser

pulse reflected back to earth and timed would give 15-cm accuracy in intercontinental distance compared with about 10-meter accuracy in other satellite methods that were described. Classical methods with modern instruments give 1-meter accuracy in a year.

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The scientific program at Stresa was organized by William Markowitz. Local arrangements were ably carried out by F. Zagar of the Observatory of Brera, Milan.

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Schladming School Examines Special High-Energy Problems

Theoretical physics in general, high-energy physics in particular are characterized by ever increasing specialization and growing predominance in abstraction. To some extent both of these tendencies are inevitable as physics progresses toward more and more details in a microcosmos of smaller and smaller dimensions, but perhaps this is carried too far today. The theory of elementary particles is presently in its infancy or certainly no further than the kindergarten stage. No great unifying ideas have shown up in the theory of elementary particles comparable to Einstein's 1905 photon paper, his 1917 derivation of Planck's law, Bohr's 1913 papers on atomic structure, Kramers's and Heisenberg's 1925 dispersion paper and the quantum-mechanics papers of De Broglie, Schrödinger, Heisenberg, Born, Jordan, Dirac and Wigner. We are, we hope, in a stage similar to that of quantum theory before the advent of quantum mechanics.

In this situation I think that schools of theoretical physics, winter or summer, have perhaps even greater significance than symposia. As the well known Les Houches Summer School is the brainchild of Cécile DeWitt, the Schladming Winter School of Theoretical Physics held each year since 1962 is the brainchild of Paul Urban, director of the Institute of Theoretical Physics at the University of Graz, Austria.

But although topics at Les Houches change from year to year, topics at the Schladming school are always in elementary-particle physics. The last three schools were concerned with

Weak Interactions and Higher Symmetries, Quantum Electrodynamics, and Elementary Particle Theory, respectively. The proceedings have been published in *Acta Physica Austriaca* (of which Urban is editor) as Supplements I, II, and III, the latter also as a hard-cover book.¹ This year's school was on Special Problems in High-Energy Physics. Approximately 170 physicists attended.

Directions for young people. There is a tendency to invite people to symposia who are at least somewhat established although, as the past has shown, new ideas most often come from young people perhaps not yet established. Furthermore, since everything is in a flux, there are various directions toward which the "established" people guide their doctoral students. Thus postdoctoral people (and predoctoral as well) who come to such schools naturally are specialized, and it is important that they be exposed to a spectrum of directions and also come into contact with a spectrum of people from various institutions.

Two general directions in the theory of elementary particles are field theory and its offspring, S-matrix theory. The first tries to extend the field theory of quantum electrodynamics to weak and strong interactions. The second is perhaps more restrictive in emphasizing the S-matrix as the main observable object.

Field theory. At Schladming an example of the first direction was Gunnar Källén's (Lund) talk on "An Attempt to Calculate Radiative Corrections to a Pure Fermi Decay".² He gave a general survey of his calcula-

tions of the radiative corrections to beta decay, emphasizing the influence of nucleon structure in general and nucleon form factors in particular. The first calculations of such corrections assumed a simple point-particle model, for example, Dirac particles without structure and without anomalous magnetic moment. They lead to a logarithmically divergent result, necessitating an arbitrary cutoff. The main conclusion of the paper is that the appearance of the logarithmic divergence can be eliminated if strong interaction effects are taken "properly" into account.

An example of an intermediate approach between field theory and S-matrix theory was the lecture series of Fritz Rohrlich (Syracuse) on "Asymptotic Quantum Field Theory".³ This theory differs from the better known axiomatic quantum field theory in approach but not in content. Both theories aim toward a more satisfactory formulation of quantum electrodynamics avoiding renormalization. Asymptotic theory supposedly permits a wider use of physical intuition in contrast to mathematical rigor, which characterizes the axiomatic approach. Until now, however, the results of quantum electrodynamics could be reproduced only by using perturbation theory but with the claim that the calculations did not involve divergent integrals or renormalization.

S-matrix theory. John C. Polkinghorne's (Cambridge U.) lectures on "S-Matrix Singularity Structure"⁴ were more mathematical. The principal properties of an S-matrix are unitarity, Lorentz invariance, connectedness structure, analyticity and crossing symmetry. The purpose was to make as precise as possible the meaning of the "somewhat oracular requirement," that the singularities are the "minimum permitted by analyticity." One can show, that "all physical-region singularities occur only on the positive alpha arcs of Landau curves, and their discontinuities are given by Cutkosky integrals. The problem of singularities outside the physical region still remains."

"Superconvergence and Current Algebras" was the topic of the lectures by V. de Alfaro (Torino). The PCAC hypothesis (pion-pole dominance of axial-current divergence), coupled