## MAY LECTURE

At the 4 May meeting of National Capital Astronomers Dr. Gernot M.R. Winkler, Head of the Time Service of the U.S. Naval Observatory, described some of the present ways time is measured and defined and discussed their evolution. Astronomy's business is to measure time, not to define it. However, time has to be measured in several conceptually different ways, so the definitions were a necessary part of the presentation.

Time is both the most fundamental and the most confusing of all physical measurements, and is involved in many other physical measurements. Time is inherently a macroscropic quantity which becomes vague at very small time intervals. Heisenberg's uncertainty princise requires this: time and energy cannot both be measured for a system without generating a certain minimum error.

Time is a subjective concept; reason operates serially. however, we can discuss it in two different frameworks which we call subjective and objective. Subjectively, only the present exists. Objectively, we can assert the existence of past, present, and future. Subjective time is process-oriented, with a concept of causality. From an objective viewpoint time is static, with geometry taking the place of causality -- Weil asserted that the the world does not happen, it merely exists. Einstein saw real meaning in past, present, and future.

Until the end of the 19th century the rotation of the Earth gave *the* measure of time. Long before, however, Kepler already suspected that the rotation of the Earth was not uniform. In 1876 Newcomb compared the second in mean solar time (defined by the rotation of the Earth) and in ephemeris time (ET -- defined by the Earth's orbital motion). He found real evidence of a difference which became unmistakable by the end of the 19th century. In the 1930's mean solar time (now replaced by universal time, UT) was found to exhibit not only secular variations, but seasonal changes as well. Where could a uniform, invariant time-interval reference be found?

Dr. Winkler stressed the fact that such uniformity is a purely subjective concept! If many clocks agree closely with each other over an extended time, we adopt their measured intervals as "uniform," albeit a subjective concept.

To meet the need for such a time-interval reference, the atomic clock was developed in the early 1950's. Using the frequency of a spectral line in the microwave hyperfine-structure spectrum of cesium, the atomic (cesium) clock provides an interval independent of environmental effects such as friction, temperature, humidity, and the vagaries of the motions of the Earth and other celestial bodies (except for relativistic effects). Cesium clocks agree to within one part in 100 trillion. (Ed. note: The first cesium clock was developed in 1951-2 at the National Bureau of Standards under the direction of Dr. Harold Lyons, by J.E. Sherwood (chemist) and R.H. McCracken (electronics engineer and your editor). Lyons' group first measured the line at 9,192.6318 MHz.) The cesium frequency was measured in terms of ephemeris time. The measurement, later refined by Markowitz at the U.S. Naval Observatory, became the definition of the atomic second: 9,192,631,770 vibrations of the cesium atom.

The atomic second (SI) was adopted in 1967, and the first leap second, which enabled ET and atomic time (AT) to remain reasonably synchronized, was decreed in 1972. Leap seconds are added (or subtracted) as necessary in the last minute of December or June. (Ed note: The last minute of 30 June 1985 will contain 61 seconds. Listen to WWV on 2.5, 5, 10, 15, or 20 MHz at 23:59 UT (6:59 pm EDT) 30 June and count the seconds!)

Ephemeris time was replaced in 1984 by dynamical time (DT), which contains relativistic terms. UT is related to the length of the day; ET and DT are based on orbits, and are regarded as more fundamental than UT. Because atomic clocks agree with each other more closely than they do with UT or ET/DT, they constitute the adopted standard. That is, the time they keep (actually the average of many atomic clocks) is arbitrarily called real time. This notion is justified somewhat by the fact that the time-keeping process of atomic clocks is far better isolated from the variable outside world than are those of any other clocks. They exist very nearly in inertial space.

The classical instruments for measuring time (UT) are transit instruments, now of decreasing importance, the photographic zenith tube (PZT), and the Danjon astrolabe. These use the stars as reference points. Long-baseline interferometers reference distant galaxies, which can reasonably be assumed to have no detectable proper motion. A major difficulty with the interferometers is in establishing a relation with the optical instruments; the two classes have few reference points in common. There are methods using dynamical references: Radar ranging to the Moon, and the LAGEOS and TRANSIT satellites. The ring laser uses an inertial reference.

All clocks work by continual, almost identical repetitions of some process. They furnish a count, and provide state markers (seconds). Time measured by any clock is macroscopic, local, and subject to a random-walk error.

All events on the Earth change its rate of rotation. As "time of day" is a measure of time we necessarily use in practice, leap seconds are used to keep UT, ET/DT, and AT in agreement within a second.

We list some of the causes of variations in UT. One is movement of the Earth's rotation poles over its surface. Solar effects and terrestrial currents generate seasonal variations in UT. Coupling of rotation with mantle and core



## OCCULTATION EXPEDITIONS PLANNED

Dr. David Dunham is organizing observers for the following grazing lunar and asteroidal occultations. For further information call Dave at 585-0989.

| UT Date | Time | Place | Vis Mag | Pcnt Sunlit | Cusp Angle | Min Aper |
|---|---|---|---|---|---|---|
| 06-11-85 | 08:06 | Burtonsville, MD | 7.0 | 40 | 11N | 5 cm |
| 06-28-85 | 01:28 | Fayetteville, NC | 4.6 | 75 | 17N | 2 cm |

## NCA SCIENCE-FAIR AWARDS TO BE PRESENTED

Two Washington area science-fair finalists, Matthew Gallelli, of Bethesda, Maryland, and Andrew Sheedy, of Arlington, Virginia, will be awarded one-year NCA junior memberships at the 1 June meeting

## NCA WELCOMES NEW MEMBERS

Benjamin C. Burke
4444 Alton Place, NW
Washington, DC 20016

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Bethesda, MD 20817

Robert S. Kaeser
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Rockville, MD 20850

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Andrew Sheedy
916 N. Larrimore Street
Arlington, VA 22205

Thomas E. Van Brunt
31413 Ashby Street
Alexandria, VA 22305

Alan Zabel Family
11205 Blackhorse Court
Potomac, MD 20854

## A LETTER TO THE EDITOR

Dear Bob:

Thank you, the other trustees, and the members of NCA for electing me President. I will do everything in my power to maintain the high standards and ideals of NCA that have been so characteristic of the organization for the past five decades.

Certainly our fiscal year 1986 promises to be one of the most exciting ever:

First, the return of Comet Halley, which has sparked an interest in astronomy in almost everyone.

Second, The Soviet Intercosmos Council's VEGA 1 and VEGA 2, launched last December, will deploy landers on Venus this year, and the main bus will continue, to join the craft of the United States, Japan, and the European Space Agency for the International Halley Watch in March 1986.

Third, the launch of the Hubble Space Telescope in 1986 will open new doors to our universe, much as did Galileo and his telescope.

But for 1985-1986 to be successful for NCA we need the help, expertise, and ideas from all our members. I urge all to get involved. The rewards are worth it. I welcome comments.

Yours very truly,
Stanley G. Cavelti
Stanley G. Cavelti
11621 Chapel Road
Clifton, VA 22024

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movements produce changes detectable over decades as does rebound of the shape of the Earth since the the ice age. Tides produce secular changes.

Ephemeris/dynamical time is the independent variable in Newcomb's theory of the (apparent) motions of the Sun. In practice we now use the improved lunar ephemeris (ILE). Markowitz has compared DT with the Jet Propulsion Laboratory's numerical integrations. He finds the 9,192,631,770-Hz rate of the standard cesium clock agrees, but there is a persistent additive discrepancy.

There are problems with optical measurements. Precession is one, and the choice of standard reference data is another. There is atmospheric refraction, and delays both due to water vapor and the ionosphere. These make the PZT the most accurate instrument for optical measurement of time. Varying star brightness can bias data.

The atomic time standard is not a single clock. Instead, it combines the readings from many atomic clocks of several different types. There are several ways of combining these: averages using only good clocks, plotting of clock differences, or the use of a steering algorithm. The International Bureau of Weights and Measures in Paris makes the official comparisons and publishes them monthly.

For convenience in calculations there are many additional ways of measuring time. However, there must be and is only a single adopted standard, international atomic time (IAT). John .B. Lohman

## EXCERPTS FROM THE IAU CIRCULARS

1. February 24 -- Filippenko, University of California, and Sargent, California Institute of Technology, obtained high-quality spectra of the rapidly variable X-ray source HO 323+022 with the 5-m Hale telescope. They show that the object is an extragalactic BL-Lac object rather than a galactic star.

2. March 27 -- Peters, University of Southern California, obtained spectra of the active Be star μ Cephei showing Hα emission lines in place of the usual absorption. Not seen on the 25th, the emission was stronger on the 30th. Hanuschik, Ruhr Universität, found no emission lines on April 4, 23, and 24 with the 61-cm telescope at La Silla, Chile.

3. April 3 -- Parmer and White, EXOSAT Observatory, ESA, detected a bright new X-ray transient during a slew maneuver with the spacecraft. Later a pointed observation located the source, EXO 1846-031, in Aquila, just north of Scutum.

4. April -- Taylor, University of Groningen, and Seaquist, University of Toronto, discovered a radio outburst and jet from CH Cygni with the VLA antenna. Three colinear sources extending over 0.4 arcseconds were observed and an expansion velocity of at least 3000 km/sec was derived.

## SUMMER *EXPLORING THE SKY* PROGRAMS SCHEDULED

The summer NCA public park program series, presented joomtly by NCA and the National Park Service, will be held on Glover Road south of Military Road, NW, near Rock Creek Nature Center at 9:00 pm on June 15, July 20, August 17, on September 14 at 8:30 pm, on October 12 at 7:3:0 pm. For information, call John B. Lohman, (703) 820-4194.

## NASM PLANETARIUM PRESENTS FREE LECTURES

On Saturday, May 4, at 10:00 am, NASM staff and NCA member Joseph N. Tatarewicz will speak on lunar photography in the planetarium of the National Air and Space Museum.

On Thursday, June 20, at 7:30 pm, Frank J. Low, a senior research professor at the Steward Observatory of the University of Arizona, will speak on the search for other planetary systems, in the planetarium.



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FIRST CLASS

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# NIEDNER: NASA AND COMET HALLEY; SCIENCE - FAIR AWARDS

DR. NIEDNER

Dr. Malcom B. Niedner, Jr., Laboratory for Astronomy and Solar Physics, will speak at the June 1 meeting of National Capital Astronomers. He will address NASA's plans for comet research, with emphasis on three projects: The International Halley Watch, Astro-1, and the International Cometary Explorer, the first space mission to a comet.

The annual NCA Science Fair Awards will also be made at the June meeting.

For nearly as long as comets have cast a spell on humankind, they have frustrated the astronomers who attempted to study them. The arrival of Halley's Comet to the inner solar system in 1985-86 represents a unique chance to plan for a bright comet whose behavior at past apparitions encompasses the full range of cometary phenomena. Halley will be observed from the ground, from Earth orbit, and *in situ*, and the crop of data which emerges from this array of programs and missions promises to be truly staggering. Malcom B. Niedner, Jr. received his Ph.D in astronomy from Indiana University in 1979, and immediately went to NASA GSFC to continue his work on comets, specifically, their interaction with the solar wind. Dr. Niedner has published 15-20 papers in this field and has become a known authority in it. He is Deputy Discipline Specialist for the Large-Scale Phenomena Discipline of the International Halley Watch. He is Chairman of the Astro Halley Science Team, and serves as Scientific Consultant for the International Cometary Explorer Project. His major research result addressed the phenomenon of disconnecting plasma tails of comets, which is thought to result from an interaction of comets with the magnetic field which is carried from the Sun by the solar wind. This work has added an important dimention to the use of comets as natural probes of the interplanetary environment.

## JUNE CALENDAR -- *The public is welcome.*

Saturday, June 1, 6:00 pm -- Dinner with the speaker at the Ding-How Restaurant, 1221 E Street, NW. Reservations unnecessary.

Saturday, June 1, 8:15 pm -- NCA monthly meeting at the U.S. Department of Commerce Auditorium, 14th Street and Constitution Avenue, NW. Election, Dr. Niedner speaks.

Tuesday, June 4, 11, 18, 25, 7:30 pm -- Telescope-making classes at Chevy Chase Community Center, Connecticut Avenue and McKinley Street, NW. Information, Jerry Schnall, 362-8872.

Friday, June 7, 14, 21, 28, 7:30 pm -- Telescope-making classes at American University, McKinley Hall basement. Information, Jerry Schnall, 362-8872.

Friday, June 7, 14, 21, 28, 9:30 pm -- NCA 14-inch telescope open nights with Bob Bolster, 6007 Ridgeview Drive, south of Alexandria off Franconia Road between Telegraph Road and Rose Hill Drive. Call Bob at 960-9126.

Saturday, June 15, 9:00 pm -- *Exploring the Sky*, presented jointly by NCA and the National Park Service. Glover Road south of Military Road, NW, near Rock Creek Nature Center. Planetarium if cloudy. Information: John B. Lohman, 820-4194.