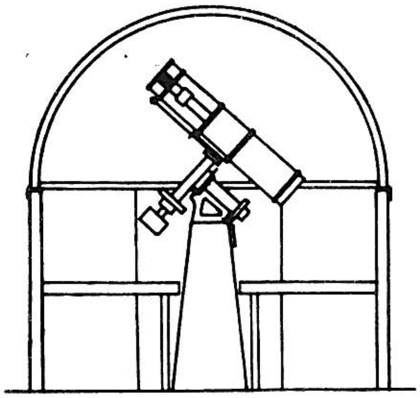
BUFFALO ASTRONOMICAL ASSOCIATION INC.
BUFFALO MUSEUM OF SCIENCE
HUMBOLDT PARKWAY
BUFFALO NEW YORK 14211



THE SPECTRUM

F E B R U A R Y 1 9 7 0

FBRUARY MEETING: Since our January meeting was cancelled due to the severe snowstorm, we have re-scheduled Dr. Chapman's talk on ORBITAL MECHANICS for our meeting on February 13, 1970 (8:00 PM, EST.) The "Ask the Experts" program scheduled for this meeting may take place at a later date. Otherwise all questions thus far submitted will be answered in these pages. We again welcome Dr. Chapman and hope for better co-operation from the weather. Refreshments after the meeting.

* * *

COMET TAGO-SATO-KOSAKA: As of this date (January 29, 1970), I have not received any local observations of this comet (of course, as usual, our weather has been somewhat less than ideal for comet viewing). Yours truly saw it on January 21, 1970, at about 7:15 PM, EST, slightly southwest of ϕ' Ceti (ca. 1° or so from that star, using 7X50 binoculars). Observing conditions were none too good: a few scattered clouds, some wind, the temperature ca. -8° F (estimated chill factor perhaps -18° F., give or take a few; the observer running a temperature of 100° F., trying to recover from the flu and otherwise insane to be out of bed!). No tail was apparent, but the nearly full moon did not help. The head looked a bit greenish and was well-defined, with a diameter of perhaps 5 to 7' of arc. With binoculars an easy and lovely sight. eeb.

*

* RECENT PULSAR STUDIES * A Report by Dr. Frederick R. West

The 131st national meeting of the American Astronomical Society was held from December 9 to 12, 1969 in New York City's American Museum of Natural History and the Hayden Planetarium. Research on pulsars was the subject of many papers and much discussion there. Pulsars are sources of radio wavelength pulses which repeat with remarkable regularity at intervals that range from 0.033 to 3.5 seconds. The pulse durations vary between 0.005 and 0.020 seconds among known pulsars. The first pulsar was discovered in 1967 by Hewish at Cambridge, England. Earlier discovery of the pulsars was difficult or impossible because of the fast response times needed from radio receivers. Because of the short time intervals involved, pulsars are thought to be small, dense objects. Most recent theoretical models of pulsars depict them as rapidly rotating neutron stars where more than one solar mass of neutrons is gravitationally compressed into a body of about 10 km radius.

Six invited review papers were presented on the morning of December 9. The first speaker was Dr. Frank Drake who reviewed current radio astronomy observations of the 46 known pulsars. In addition he surmised that if pulsars are indeed neutron stars, they are a third principal star sequence. The first sequence consists of stars which, like the Sun, are nearly perfect gases, while the second sequence which includes the white dwarfs, consists of stars that are degenerate electron gases. For stars more massive than 1.3 solar masses, the pressure of a degenerate electron gas is insufficient to prevent further gravitational collapse, which then causes the electrons to be squeezed into atomic nuclei and form neutrons from the protons in the nuclei. Models of neutron stars predict that the end result of the collapse will be an object made up almost entirely of neutrons, with mean densities from 10^{11} to 10^{15} gm/cm^3, comparable to the densities within atomic nuclei. Collapse of the star would compress any magnetic field the star might have, so that an ordinary star which collapsed to neutron star size might have a very intense magnetic field near its surface, on the order of 10^{12} gauss. A stream of charged particles that moves in phase near the velocity of light in such a strong magnetic field would emit synchrotron radiation in a narrow cone. It is possible, therefore, that an observer on the Earth would see this synchrotron radiation as a pulse whenever the combination of charged particle motion in the magnetic field and rotation of the neutron star carried the synchrotron radiation cone across the direction to the Earth. This would occur at most once every pulsar rotation. Dr. Drake termed the synchrotron radiation as "near field" radiation which occurs fairly close to the star's surface in its magnetosphere. He postulated that potential energy released during the star's gravitational collapse mostly goes into the star's magnetosphere and from there can escape as pulsed radiation. He said, however, that more gravitational energy is dissipated in the "far field" as magnetic dipole radiation than through the "near field" pulsed radiation. Also a rapidly rotating neutron star would lose energy through radiation of gravitational waves, which Weber believes he has recently detected (see Sky and Telescope 38:71, August 1969). Energy dissipated through the star's magnetosphere may cause a slow weakening of its magnetic field and slow the pulsar's spin over a long period of time, perhaps lasting billions of years. Dr. Drake suggested that such a slow "spin down", with gradual lengthening of the observed pulsation period, will allow the pulsation period range of 0.033 to 3.5 seconds to be interpreted as an evolutionary sequence. This interpretation fits our present observations, since the Crab Nebula pulsar, which is definitely a remnant of the supernova of 1054 (age 900 years), has the shortest known pulsation period (0.033 seconds).

Dr. Stephen Maran spoke next on optical observations of pulsars. Optical identification with faint blue stars has been made for many pulsars, but so far the only pulsations definitely detected in optical wavelengths have been from the Crab Nebula pulsar. He finds that although the pulsation period is the same in optical and radio wavelengths, at peak pulse intensity the radio pulses show 95% plane polarization while the optical pulses show only 10% polarization.This leads him to think that two separate mechanisms produce the radio and the optical pulses. The Crab Nebula pulsation period has been slowly lengthening; in addition, it has shown a cyclic variation in period that repeats every 3 months. Three possible causes of this periodic variation are: 1. precession of the magnetic dipole field inclined 6° to the axis of rotation, 2. slow pulsation of the star, or 3. a planet of Earth mass which revolves with the pulsar around a common center of mass every 3 months. An abrupt decrease in period occurred on September 28, 1969 which could have been caused by a shrinkage of as little as 10 microns in the radius of the pulsar!

So far the Crab Nebula pulsar is unique in that it is the only one for which pulsations have been observed in radio, optical, and X-ray wavelengths. Over all wavelengths, the Crab Nebula pulsar has a luminosity roughly 100,000 times that of the Sun. Dr. Herbert Friedman discussed X-ray observations of the Crab Nebula pulsar that have been made from high-altitude rockets. The first X-rays observed came from a source 2 light years in extent and showed no pulsation. Recently X-ray pulses from a point source have been detected. The pulse characteristics appear washed out by time delay and small angle scattering due to interstellar grains which produces the observed halo. The pulses are best observed at short X-ray wavelengths (0.1 Ångströms) and the halo appears largest at long X-ray wavelengths (10 Ångströms).

The next three papers were theoretical in nature. Dr. Thomas Gold discussed the roles of the rotational energy and conservation of magnetic flux in the collapse of an object to form a neutron star. He predicts neutron star models with large rotational energies (10^{52} ergs) and magnetic fields of 10^{12} gauss. Due to rapid rotation and strong magnetic field, the magnetic field will rotate relativistically not far from the star. Thus the magnetosphere of a pulsar will be much more complex than the Earth's magnetosphere. Secondary scattering in the magnetosphere may account for the high-energy radiation (X-rays and Gamma rays) being observed as much less intense in the Crab Nebula pulsar than the above pulsar model predicts.

Dr. Ostriker pictured pulsars as rapidly rotating dipoles. In particular, he considered the Crab Nebula pulsar as a magnetic dipole, and found a predicted age close to 900 years. The observed "spin-down," however, does not agree with that predicted by this theory. "Spin-down" and weaker magnetic fields are predicted for older pulsars; periods of pulsation near 3 seconds would be reached at 100,000,000 years age. Periods longer than 3.5 seconds have not been observed; perhaps something turns off pulsars at this age. Ostriker also predicted a formation rate of one every 300years in the galaxy, comparable to the predicted frequency of supernovae.

Dr. Peter Goldreich discussed the electrodynamics of a pulsar's near magnetic field. He found a tremendous potential difference between the poles of the pulsar due to the rapid rotation, and that the motion of charged particles in the star's magnetosphere produces high-energy synchrotron Gamma rays and pairs of electrons and positrons. The strong magnetic field near the pulsar, however, causes the wavelengths of Gamma radiation to be increased before it escapes the magnetosphere.

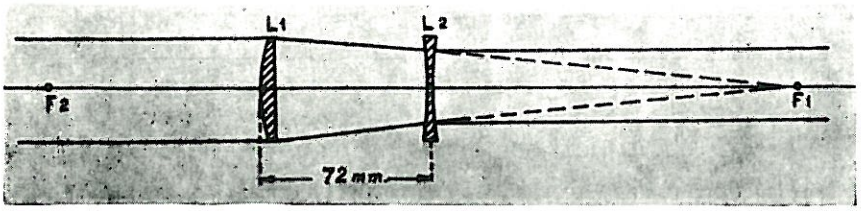
During the rest of the meeting, many other papers dealt with work on pulsars. Nine papers were on pulsar observations, optical identification of pulsars, and X-ray and optical searches for pulsation. Ten papers were theoretical studies of pulsars and neutron star models. The papers ranged from a tentative equation of state for neutron stars to observations of the Crab Nebula pulsar before, during, and after an occultation by the Sun, with the purpose of finding the electron distribution in the solar corona!

An immediate future need is for successful detection of more optical and X-ray pulses, so that observations of these other pulsars can be used to check theoretical models and conclusions that are based on the extensive observations of the Crab Nebula pulsar which have been obtained recently. Also a means to determine the distances to pulsars other than the Crab Nebula is badly needed.

* * *

DID LEONARDO DA VINCI INVENT THE TELESCOPE? (The following is based on an unsigned article, "The First Telescope: Was it Leonardo's?", Optical Spectra, July/August 1969, 122/123. The article was kindly sent to us by Ray Manners).

It is generally conceded that the first workable telescopes were produced by the Dutch spectacle-maker Hans Lippershey around 1608. There are, however, earlier claims, for example one favoring Roger Bacon in the 13th century. There appears to be also some evidence that Leonardo da Vinci described a complete telescope with eyepiece in 1508. The evidence is discussed by Domenico Argentieri in a chapter entitled "Leonardo's Optics" in the volume Leonardo da Vinci (New York: Reynal and Co., Inc., 1956). One entry in Leonardo's notebooks reads: "Make glasses in order to see the moon large." According to Argentieri, a drawing in Ms. F, fol. 25r represents a description and diagram of a telescope. The drawing shows a short thick tube on a support with a convex lens at one end and a negative lens, "thick at the edges and thin in the middle" at the other. In another notebook is outlined a general theory of the telescope, as follows: "It is possible to find means by which the eye shall not see remote objects as much diminished as in natural perspective, which diminishes them by reason of the convexity of the eye ... the convex pupil of the eye can take in the whole of our hemisphere, while this method will show only a single star. But where many small stars transmit their images to the surface of the pupil, those stars are extremely small; here only one star is seen, but it will be large. And so the moon will be seen larger and its spots in a more defined form." It is not known whether Leonardo ever actually constructed a telescope - he probably never did. But one cannot help wondering what might have happened. had the telescope been used astronomically one hundred years before Galileo!



The figure on the left is a schematic reconstruction by Argentieri of an interpretation of Leonardo's notes.

* * *

PARTIAL LUNAR ECLIPSE: On the morning of Saturday, February 21, 1970, a short partial eclipse of the Moon will be visible from Buffalo. The Moon enters the umbra at 3:02 AM, EST and leaves it 56 minutes later. About 1/20 of the Moon's diameter will be in shadow. The museum's Kellogg Observatory will be open to the public from 3;00 AM to 4:00 AM.

* *

Buffalo Astronomical Association, Inc.
c/o Buffalo Museum of Science
Buffalo, N.Y. 14211

FIRST CLASS

Mr./Mrs. Duane Sundell
4495 East Overlook Dr.
Williamsville, N. Y.
14221