Radioastronomy of Interstellar Gas

Radio Astronomy had its beginning in 1932 when Karl Jansky found that the noise in early radio telephone circuits was periodic with the rotation of the earth. Since that time large radio telescopes and very sensitive receivers have been built which allow radio astronomers to study many parts of our Galaxy which are inaccessible to optical astronomers.

Recently molecular lines have become very important in studying the clouds of gas and dust which inhabit the regions between the stars. These clouds are the material out of which stars and planets condense. In the past three years a number of complex molecules have been discovered in these clouds by means of their radio spectrum. Molecules identified include: amonia, water, formaldehyde, carbon monoxide, cyanogen, hydorgen cyanide, cyanoacetylene, methyl alcohol, formic acid and the hydroxyl radicle.

The radio lines from these molecules provide astronomers with a very important means of determining the velocity, turbulence, temperature and density of interstellar clouds. Some of the molecules also exhibit characteristics of maser emission and refrigerator absorption which are apparently related to the peculiar physical conditions of the cloud. The temperatures and densities are extremely low while the velocities and distances are very large. The chemical evolution in these is very advanced and complex organic molecules are present in relatively large abundance. The study of interstellar clouds suggests that the evolution of living things on earth may have had its beginning inside a similar cloud five billion years ago.

Doctor David Buhl graduated from MIT in 1960 with a Masters in electrical engineering. He then went to the Lawrence Radiation Laboratory in Livermore, California for three years where he worked on a variety of engineering projects including an infra-red television transmission system. The next three years were spent at the University of California at Berkeley on the topic of radiation anomalies in lunar craters, where he obtained his Ph. D. In 1967, Dr. Buhl joined the scientific staff of the National Radio Astronomy Observatory where he found himself in
In addition to radio observations of the Moon and Sun, he has been involved in an interferometer project to determine surface temperatures on the planet Venus and some studies of the radio emission from the radiation belts of Jupiter. Over the past three years Dr. Buhl and Dr. Lewis E. Snyder have been actively pursuing molecular lines in the interstellar medium. Coming in second on the detection of water vapor clouds in the Galaxy, they went on to discover formaldehyde, hydrogen cyanide and Xogen (a quote, not a misprint, ed.). Since these molecules are important to the chemical evolution of life, Dr. Buhl and Snyder are continuing to look for other links in the evolutionary chain.

The Light of Mercury and Other Elemental Facts

In recent weeks my mail has brought glimmers of hope in the problem of excessive outdoor lighting. One is the recognition of the problem by a conservation organization and the other is favorable action by a zoning board.

Included in the Fall 1970 Progress Report of the World Wildlife Fund (910 17th St. N.W., Wash. D.C.) is a pamphlet written by Malcomb B. Wells of Cherry Hill, New Jersey. This lists a dozen areas in which man has made a mess of things and what he can do about each of them. I quote the last item on the list.

"Destruction of Night -- Night totally destroyed; a whole generation made unfamiliar with the wonder of darkness, of the moon, and of bright stars. Possibly one of the biggest treats of all, but it's too soon to tell yet. Unless a lot of us care there is not much we can do. Kiss the stars goodbye, I guess and get ready to tell our grandchildren why we wrecked so many wonders. How the wild animals and plants are affected by this lighting madness no one knows - and few care. Strict laws, overdue even now will limit artificial lighting to the surfaces that need light and prevent all light spillage into the sky and into others eyes."

The second item is Bob Wright's letter to the November issue of Reflector which quotes the lighting ordinance passed by a zoning board in the area of the new observatory site of the Lehigh Valley Astronomical Society.

It is encouraging to see that someone besides astronomers care and are becoming concerned and that lighting ordinances can be enacted.

If further progress is to be made there must be more publicity and it must come from we who are most directly concerned. Cooperation through the astronomical societies is needed but we as individuals should not wait for a committee to act. We can each get a word in whenever the opportunity arises when speaking to groups or individuals or by writing letters or school essays. How about some of the Juniors using "Dark Pollution" as the subject of a Science Fair Project?

Lyle T. Johnson.
Now is the time for NCA Junior members to plan astronomical projects for exhibit in the Spring Science Fairs. In past years, NCA members' projects have won many awards, frequently going to a hard core of serious amateurs. I'd like to see more and better competition. To be really successful, a project based on some astronomical theory requires many months of study and planning for successful execution. A project based on astronomical observation requires the choice of a narrow enough area, optimum use of the instrumentation available and good luck with the weather. NCA awards free one-year memberships to the best exhibitors in the county-wide fairs. Good Luck!!

One interesting result from the Orbiting Astronomical Observatory II is that OH (hydroxyl) radical exceeded cyanogen and molecular carbon in quantity by several hundred times in comets Bennet and Tago-Sato-Kosaka. This means that water-ice as well as methane ice was present.

The Saturday Star for December 13th had an excellent short feature article on Dr. Werner VonBraun of NASA, in its magazine section.

The officers and trustees of NCA wish all members a happy and prosperous New Year.

There will be no solar eclipse this year but we can look forward to a total lunar eclipse on February 10th and a very close approach of Mars in August. I hope to interest NCA observers in a program of simultaneous observation of the planets beginning with Saturn in February continuing with Jupiter during the spring and culminating with extensive drawing of Mars this summer. Plans for this program of Friday or Sunday evening observing will be formulated at the January 23rd discussion group and announced at the February meeting.

A thorough check of the possibility of having the NCA mailing list serviced by the National Bureau of Standards conducted by Jerry Hudson and myself revealed that this privilege is open only to those societies some of whose membership are participating as part of their official NBS duties.

An interesting finding from Apollo 12: In the 31 months between the landing of Surveyor 3 and the landing of Apollo 12, no new meteor craters larger than 1.5 mm in diameter were detected.

Dr. Elihu Boldt of the Goddard Spaceflight Center discussed current work in X-Ray Astronomy at the December 5th meeting of NCA. About 40 objects are now known to emit this high energy radiation having wavelengths less than 40 Å. Two of the most powerful sources are the crab nebula and a nebula in scorpius. Both balloons and rockets are used to carry instruments for this work above the limiting atmosphere. Forthcoming satellites with their major purpose the extending of the regions explored for X-ray sources will be the first devoted completely to this branch of astronomy and should greatly expand its knowledge. Such a satellite was launched by the Italians on December the 11th.
Calendar

January 9th - 6:15 PM, Dinner with the speaker at Bassin's, 14th and Pennsylvania Ave., N.W. Reservations by noon Saturday. Call Winkler 762-5135 or Legowik 946-8996.

January 9th - 8:15 PM, January meeting of NCA. Dr. David Buhl of NRAO speaks on Interstellar Molecules. Department of Commerce Auditorium, 14th and E street, N.W.

January 23rd - 8:15 PM, Discussion Group, Department of Commerce Room 2062, 14th and E, N.W. Problems of planetary drawing and plans for some NCA simultaneous planetary observation periods SPOP, will be discussed.

January 8, 15, 22, 29th. Telescope making classes, basement of the McKinley Bldg. American University Physics Building, conducted by Jerry Schnall. For more information call EM 2-8872.

January 16th, 2:00 PM, Juniors Meeting of the MD. D.C. Juniors at the Chevy Chase Library on Connecticut Avenue. For more information call Jean Radoane at 434-0443. Jerry Hudson will conduct a telescope clinic.

January 23rd, 7:30 PM, Observing at the 5-inch at the Naval Observatory with Larry White. For additional information call 461-9681.

NATIONAL CAPITAL ASTRONOMERS, Inc.
of Washington, D.C. **STAR DUST***

President: William Winkler, 1001 Rockville Pike, Rockville, Md. 20852 ** Editor: John Legowik, 3524 Hargo St., Wheaton, Maryland, 20902, Phone: 946-8996

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St. Rose Land
Princeton, N.J.
### OCCURRENCE OF 11500 NEARBY — APPROXIMATE MORTAR LIMIT — LAT. — 30° 45.6 **05** WEST LONG. — 77° 53.1

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**CHRONOLOGICAL PREDICTIONS**

Following the Phases predictions (if any) are abridged data in chronological order for the convenience of the observer. Under "REMARKS" the comments "NO CHU" and "NO WWY" (for Western Hemisphere observer only) appear when the predicted time indicates that either or both communications would possibly not be possible for that observer's local time. This happens if the predicted time plus the accuracy of transmission overlaps a "silent" period for the time signals. Other comments which may appear are "Double", "GRAIZE", "MSS", or notes about the attitude of the sun "SUN" or the star "A11".
GRAZING OCCULTATION OF Z05G90

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DAY 24 12 35 39 R 5 2617 4.7 15 96 N 33 267-2814174 180614.536-282748.97

1971 ISSUED BY U.S. NAVAL OBSERVATORY, WASHINGTON, D.C.

TOTAL

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1971 TOTAL OCCULTATION PREDICTIONS FOR WASHINGTON, D.C.

-DAY-WEIGHT-

PAGE 6 OPTIONS -- 2:1:4:7 ADDRESS CODE A123

1971 TOTAL OCCULTATION PREDICTIONS FOR WASHINGTON, D.C.

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TOTAL OCCULTATION PREDICTIONS FOR WASHINGTON, D.C.

-PAGE-
II. Column Headings

DAY TIME UT (H M S) gives the day of the month and hours, minutes and seconds of predicted Universal Time (UT) of occultation event.

$P$ is phenomena: $D$ for disappearance, $R$ for reappearance, $G$ for graze (given time for central graze; multiple events may be expected up to five minutes before or after) $M$ is for miss (line appears only because of graze near line which follows).

$D$ is double star code: $N, S, P, F$ mean prediction is for only the north, south, preceding (West) or following (East) component of the double. $M$ means double was unresolved photographically, and prediction is for mean position of components. A L, etc. refer the observer to a double star catalogue for detail (A is Alken, L is Lins, etc.).

$AC$ is estimated accuracy of prediction, in seconds. Prediction may be in error because of limb irregularities and star position and uncertainties, but by normore than the amount in this column for almost all cases.

Regular errors of larger size usually indicate a problem with the station coordinates. Please confer with USNO if this occurs.

USNO REF NO is the primary identification of the star, needed on the observation report. Four digit reference numbers are from the zodiacal catalog of Robertson (EZ). Five digit numbers preceded by the letter $Z$ are from the USNO subset of the Smithsonian Star Catalog for the zodiacal regions of the sky (EZ). Other letters designate special catalogs -- eg. $P$ for Fleissigs.

$MAX MAG$ is the visual magnitude of the star. For variables it is the maximum magnitude.

$SN ALT$ is the altitude of the Moon above the horizon. This and all subsequent quantities are in degrees, unless other units are specifically indicated.

$SN$ is the altitude of the Sun, given only when it is greater than or equal to -12 degrees (which is the edge of nautical twilight). Daytime events are also predicted when observable.

$V$ is the estimated relative value of the event for reduction purposes, with 9 being the highest value. The code approximately indicates that all visible events during the reductions are reappearances, events near new or full moon, near grazes and stars with southern declinations. It is planned to discontinue listing this code on future predictions.

$O$ is the observability code, with 9 the most easily observed, and 0 meaning not observable under any condition.

Only events rated at the observers selected observability code limit or higher appear on the predictions.

$CA$ is the cusp angle of the event. This is the angle from the nearest lunar cusp to the star. The nearest cusp is identified by letter as the North (N), South (S), East(E), or West(W), cusp. Cusp angles are positive on the dark limb and negative on the bright limb.

$ECL$ is the elongation of the Moon from the Sun. This is the angle at the center of the Earth between the Sun and the Moon. It can never exceed 180 degrees and is 0 degrees or 180 degrees only at the time of an eclipse.

$PA$ is the position angle of the event, measured at the center of the Moon's disk from the north celestial pole eastward to the star.

$DM$ REF NO is the Durchmusterung reference number. For BD numbers, the zone and four digit numbers are separated by a blank. For CD numbers, the zone and five digit numbers are unseparated.

$RT ARC (H M S)$ is the star's rate of change of the predicted occultation time for grazes and central reappearances.

$DECL (D H M S)$ is the exact apparent declination of the star at occultation.

$SP$ is the star's spectral type. For bright limb events, type G stars have the same color as moonlight, and are the most difficult to resolve. Stars with more than one spect rum (spectrum variables, double-line spectroscopic binaries) have different spectral types.

$PCT SNUT$ is the percent of the moon's disk under (100% is full moon) followed by plus for waning and minus for waxing.

$WA$ is the Watts angle of the event, measured at the center of the moon's disk from the Moon's north rotation pole eastward to the star. It is different from the axis angle only if a correction of plus 6.2 degrees has been added so that the angle can be used directly for limb correction look up in the Watts charts.

$LONG LIB$ is the moon's topocentric libration in longitude.

$LAT LIB$ is the moon's topocentric libration in latitude.

$SAO REF$ NO is the reference number of the star in the Smithsional Astronomical Observatory (SAO) catalog. O or blank indicates a star not in the SAO catalog.

$*B C (M / S / W / G / S K )$ are the rates of change of the predicted occultation time with changes in the observer's longitude, latitude and elevation, respectively. The units are minutes of time per degree of longitude or latitude (M/S) and seconds of time per kilometer (S/K). If the event is so near grazing that these quantities become useless, asterisks appear instead.

$MN AZ$ is the azimuth of the Moon, measured along the horizon from the north point eastward.

$VA$ is the vertex angle of the event, measured at the center of the Moon's disk from the south eastward to the star.

$HA$ is the hour angle of the Moon, measured at the north celestial pole from the observers meridian westward (positive) or eastward (negative) to the star.

* These quantities are not given for photoelectric option predictions. Instead the following data is given.

$BAD RATE (AS/A)$ is the topocentric radial rate of approach of the star to the Moon's limb, in arc seconds per second of time.

$DIST (KM)$ is the topocentric distance of the Moon's center from the observer, in kilometers. The Moon's mean distance is 384,400 km. The ratio of mean to true distance is the factor to be applied to Watts limb corrections to convert them to true distance. The factor distance divided by 208 km is used to convert radial rates into kilometers per second.

$CNT ANGL$ is the contact angle of the star with the Moon's mean circular limb. It is 0 degrees for central disappearance, 90° for grazes and 180° for central reappearances.

$HA (D H M)$ is the hour angle of the Moon, the same as for non-photoelectric option predictions, but given in degrees and minutes of arc.

III. Supplementary Information Lines

"GRAZING OCCULTATION OF .... NEARBY,..." draws the observers attention to a nearby grazing occultation of the preceding star on the predictions, usually within 20 to 40 miles (50 to 100 miles for the extended graze option). Ordinarily, multiple occultations will not occur at the observers station unless the phenomenon for the star was "G", and possibly not even then. The approximate location and graze limit may be drawn on a map with the aid of the formula in the meg message.

"West Long." into the formula, one can compute the corresponding latitude of a point in the limit.

"POSSIBLE LUNAR ECLIPSE" indicates that the usual testing of the magnitude of stars to determine observability codes has been temporarily suspended because the Moon may be in eclipse at the time.

"ABOVE STAR, IS A VARIABLE STAR,..." gives the minimum magnitude for variable stars. If the minimum is unknown (usually very faint) the value 99.9 may appear.

"TRIGONOMETRIC STELLAR PARALLAX OF ABOVE STAR,..." gives the parallax from the Yale Catalog in seconds of arc, when it is at least 0.010. This message appears only on predictions with photoelectric options.

MONTH of the year appears on a separate line immediately following the "readings on each page, and again whenever it changes."
OCCULTATION PROJECTS NOTICE

This notice contains information about changes in procedure for all active participants in occultation projects. Observers should take particular note of Section II.

I. Reasons for Changes: The occultation projects of both the Nautical Almanac Office, U.S. Naval Observatory, Washington (USNO) and Her Majesty's Nautical Almanac Office, Royal Greenwich Observatory, Hertsmoneux (HMNAO), are now being fully coordinated. This has led to a number of procedural changes in each office, primarily to avoid duplication of effort and to maximize the amount of scientific data obtained from occultation observations.

II. REPORTS OF OBSERVATIONS -- TOTALS AND GRAZES: Effective immediately, all reports of occultation observations, whether totals (ordinary occultations) or grazes, should be sent to Mrs. F. M. Sadler at HMNAO. No copies should be sent to USNO. All observers are requested to use the standard report forms for totals to speed up keypunching and processing of the observation reports. Analogous forms are being prepared for grazes, and will be distributed when available with appropriate instructions. North American Observers are encouraged to send their observation reports, at least of grazes, to HMNAO via air mail. The current rate for air mail from the United States to England is 20¢ per half ounce.

Both USNO reference numbers (same as Z.C. number for Z.C. stars) and the SAO number should be reported for both total and grazing occultations when given in the predictions.

III. 1971 PREDICTIONS -- TOTALS: Both USNO and HMNAO will continue to supply predictions in 1971 on essentially the same basis as in 1970. It is hoped to merge these two efforts in time for the 1972 predictions. See separate descriptions of format changes in the USNO predictions.

IV. 1971 PREDICTIONS -- GRAZES: It is not known to what extent USNO graze predictions will be available during 1971. Perhaps only to the US, Canada and some other selected locations can be covered in 1971. The HMNAO predictions, however, are more widely available and include computer produced profiles when needed. Graze maps for inclusion in a few widely distributed profiles distributed publications are being prepared at HMNAO.

V. PRELIMINARY REDUCTIONS -- TOTALS: Only HMNAO will supply observers with preliminary reductions. Generally Non-ZC stars will also be reduced in the same manner as ZC stars. Observers are advised that the residuals contain the effects of errors in the preliminary lunar ephemeris, star positions, limb corrections, etc. Star positions for non-ZC stars are especially poor. However if a large percentage of residuals are in excess of 1. "5, an error in the observer's coordinates or in the timing procedure is usually indicated.

VI. PRELIMINARY REDUCTIONS -- GRAZES: Preliminary reduction profiles for many grazing occultations prepared by Ronald Abileah (U. of Miss., Kansas City) were distributed to the observers involved during the past year. The preparation of the machine data for all other graze observations which have been reported is nearing completion. With the help of the Watts chart in machine-readable form (see section VIII) Mr. Abileah hopes that the preliminary reduction profiles for all these grazes can be produced by machine and distributed to observers in 1971.

Reprints of an article, "On the Orientation of C.B. Watts' Charts of the Marginal Zone of the Moon", published in MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY, can be obtained upon request to the author, L.V. Morrison, HMNAO. The study is based primarily on graze observations and details one area where such observations are used.