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THE OHIO STATE UNIVERSITY
RESEARCH FOUNDATION

Report No. 1

RF Project 480

REPORT

By

THE OHIO STATE UNIVERSITY
RESEARCH FOUNDATION

COLUMBUS 10, OHIO

Cooperator AF CAMBRIDGE RESEARCH LABORATORIES
230 Albany Street, Cambridge 39, Mass.
Contract AF 19(604)-41

Investigation of FLUCTUATIONS OF STARLIGHT AND SKYLIGHT

Subject of Report Progress for the period October 1, 1951 to December 31, 1951

Submitted by J. Allen Hynek

Date March 15, 1952

"Submitted to the Geophysics Research Division, Air Force Cambridge Research Center, Cambridge, Mass. The work reported here is of a preliminary nature and the results are not necessarily in final form."

ABSTRACT

During this initial period two principal ventures were undertaken:

(1) the design and construction of a photoelectric photometer employing a 1P21 photomultiplier tube, for use with the 12.5-inch refracting telescope of the McMillin Observatory. The photometer features interchangeable filters and diaphragms and a solid CO_2-cooled tube chamber. The smallest diaphragm will admit only one square second of arc of sky, a unique feature of this photometer.

(2) an extensive survey of the literature, the objective of which is a critical technical report of essentially all known previous work on the problem of astronomical seeing. This report should serve as a critical guide not only for our staff of workers, but for other workers in this field.

The design and construction of the photometer was under the direction of Dr. Geoffrey Keeler and Dr. Charles Shaw, with Mr. Protheroe in charge of the electronic recording components. The critical survey of the literature is under the direction of Dr. J. A. Hynek, with Mr. Roger Hosfeld as the chief library research worker.

INVESTIGATIONS IN PROGRESS

(1) Choice and Design of Equipment

Obtaining the observational results that are sought depends on the construction of specialized equipment. The equipment necessary on this project is, first, a telescope of sufficient power to produce an appreciable and measurable tremor disk of a star in the daytime, and second, a device to make a permanent record of the behavior of the image.

The telescope to be used in this work is the 12.5-inch refractor of the McMillin Observatory which will be made available for as many hours as are needed. The telescope is in excellent condition and is operating well. No alterations on the telescope are contemplated, with the possible exception of improving the drive mechanism if this should prove necessary.

The electronic means for recording the fluctuations of the star image, however, must be constructed and assembled ab initio, owing to the highly specialized character of the proposed investigation.

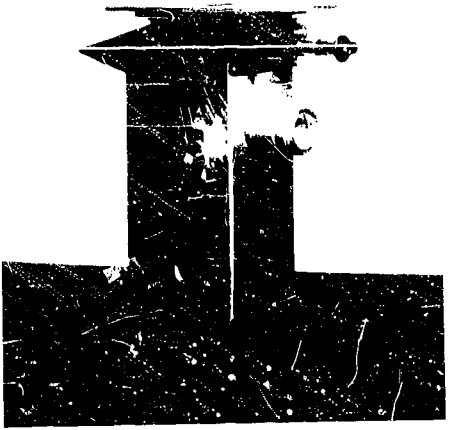
At the initiation of this contract work, therefore, numerous consultations were held by Drs. Keeler, Shaw, Hardie and Hynek, and by Messrs. Protheroe and Hosfeld, among themselves and with other astronomers as to the most appropriate equipment with which to accomplish the project work. It should be pointed out that although Dr. Hardie and Mr. Hosfeld were not project staff members during this period, they gave freely of their time in the discussions and contributed valuable advice.

Dr. Hynek visited the Naval Observatory, where similar work is in progress, to consult with Dr. John Hall, director of this work. One of the primary results of this visit, and subsequent correspondence, was a cooperative agreement between the Naval Observatory and the McMillin Observatory which will eliminate needless duplication of effort. It was further agreed that there shall be frequent and free interchange of ideas and information. This plan is working out very well, and Dr. Hall and his associates are to be commended for their cooperation and devotion to the principles of the free discussion of scientific results.

It was agreed that the Naval Observatory shall continue to specialize in the analysis of the frequency components of stellar scintillation, particularly the very low frequency components, and upon night time astronomical seeing. Our staff, on the other hand, is to concentrate on daytime astronomical seeing, on the quality of the scattered blue daylight sky, and upon the extension of the study of astronomical seeing, both day and night, to the near infrared.

The discussions reported above had a direct bearing on the choice and design of our equipment. It was decided to concentrate on the construction of a highly specialized photoelectric photometer as the primary piece of equipment, to be used directly with the telescope.

The state of construction of the photometer, as of Dec. 31, 1951, is shown in the accompanying photographs. In (a) is shown the optical part of the photometer. The plate shown at the top attaches directly to the double-slide mechanism of the telescope camera housing.



(a)
Optical Part
of the
Photometer

(b)
Cooling Chamber
for the
1P21 tube

Shown immediately below are two eyepieces. The uppermost is a guiding eyepiece. This is movable over the entire field and is used solely with an auxiliary star that serves as a "guide star", enabling the observer to insure that the telescope is guiding properly and that, therefore, the star actually being recorded is playing directly upon the entrance diaphragm of the optical system.

The wider, shorter eyepiece below the guide eyepiece looks directly into a 45° mirror which can be flipped in and out of place. When the star to be recorded is on the cross wires of this eyepiece, the observer is assured that when the mirror is flipped away (by the hand wheel on the side) the star is exactly on the entrance diaphragm of the optical system.

In view of the extremely small diaphragms used (to exclude the maximum amount of daylight sky) it is highly important that the viewing mirror system be very accurately machined and aligned.

Various diaphragms have been mounted on a wheel, controllable from the outside and yet light-tight, so that the variable size of the tremor disk can be properly accomodated.

Immediately behind the entrance diaphragm is placed a Fabry lens, which images the objective of the telescope (rather than the star) on the cathode of a 1P21 photomultiplier.

A wheel, similar to the diaphragm wheel but containing a number of Jena and Corning filters, is placed in the optical train before the phototube so that fairly narrow regions of the spectrum (from ultraviolet to infrared) can be admitted to the cell. (An infrared filter was included even though the 1P21 tube is insensitive to this spectral region, in anticipation of the possible use of a PbS cell.)

Photograph (b) shows the cooling chamber for the 1P21 tube. The base of the tube is to be removed, and the leads soldered to brass plates which butt directly against a plug of "dry ice", kept in constant contact with the plates by spring tension. (This part of the design was copied in part from the night time stellar photometer constructed by Dr. Seyfert of the Barnard Observatory at Nashville, Tenn.)

Standard power supplies feed the stages of the 1P21 multiplier. Its output will be recorded on a standard device such as a Brush recorder or a magnetic tape recorder. This part of the electronic train is essentially standard equipment and need not be elaborated upon here.

(2) Survey of the Literature

At the close of this report period, an intensive survey of the literature had been initiated by Mr. Hosfeld, even though he was not formally on the project until Jan.1, 1952. The Ohio State University general library and the astronomical library of the Perkins Observatory were used as the principal sources of library material.

During this report period the 69-inch reflecting telescope of the Perkins Observatory, the facilities of which are also available to our project staff, was used to examine the manner in which starlight illuminates the mirror of this telescope in the daytime. This is done by placing the eye at or near the focus of the telescope and looking out the large mirror. The eye thus acts as a Fabry lens and one sees the entire objective illuminated by the starlight.

Long focal lengths are necessary to accomplish the observation of a star-illuminated objective in broad daylight. It can be done with

ease with the 104-foot focal length of the large Perkins reflector, but is virtually impossible with a 15-foot focal length telescope.

We expect to learn a great deal about daytime seeing by a study of the illumination patterns of the 69-inch mirror of the Perkins telescope.

OTHER SCIENTIFIC ACTIVITIES

Conferences

As was noted above, conferences were held with the Naval Observatory staff concerned with similar work.

Correspondence

Copies of two communications from Naval Observatory staff and administrative personnel relative to the agreements entered into with them by Dr. Rynek in the interests of mutual benefit and the elimination of duplication are reproduced herewith (pp. 8 and 9).

It will be noted that overlap is not excluded in these agreements, when it appears profitable to either party. It is the unanimous opinion of our staff that the cooperative arrangement agreed upon is mutually advantageous and that it will enhance without in any way impairing the contract work we are embarked upon.

EXCERPT FROM MEMORANDUM OF 21 NOVEMBER 1951

Op-26
A19
Ser:1517P26

From: Superintendent, U. S. Naval Observatory
To: Bureau of Ordnance (Code RE9 - Attention Mr. M.J. West)

Subj: BuOrd Project No. 16733

1. Recently it came to the attention of the Superintendent that the Air Force had let a contract to Ohio State University to make investigations under the direction of Dr. Hynek similar to BuOrd Project No. 16733. The obvious thought occurred that considerable advantage might be gained if these projects were coordinated on a mutually agreeable basis. Discussions of this were held on 16 November 1951 with Dr. Hynek incident to an unexpected visit of the Doctor to the Observatory. Dr. Hall, Mr. Hoag and Mr. Mikesell attended these discussions for the Observatory.

2. Dr. Hynek is most desirous of effecting free exchange of information and ideas to avoid useless duplication. He is also agreeable to the establishment of fields of primary effort to be pursued by each of the Observatories. If the Bureau of Ordnance has no objection, it is the intention of the Superintendent to authorize on a trial basis this cooperative exchange of information and the establishment of fields of primary effort as set forth below:

a. Throughout the course of these investigations free exchange of ideas and results is to be maintained.
b. The U. S. Naval Observatory will primarily concern itself with (1) the extension of its scintillation measurements to the subsonic range, and (2) efforts to determine at what atmospheric levels scintillation occurs.
c. The Ohio State Observatory will be primarily concerned with (1) scintillation measurements in the daytime sky with particular reference to the changes in scintillation with angular distance from the sun, and (2) scintillation measurements in different regions of the spectrum - particularly in the infrared.
d. No effort will be made to eliminate the overlap expected in the two programs, as on examination such appears highly desirable.

F. A. GRAY

cc: Dr. J.A. Hynek

EXCERPT FROM MEMORANDUM OF 2 DECEMBER 1951

Re9a-RJW:gs
A1-1

From: Chief, Bureau of Ordnance

To : Superintendent
U. S. Naval Observatory
Washington 25, D. C.

Subj: Bureau of Ordnance Project No. 16733 and Air Force contract with Ohio State University; coordination of

Ref : (a) USNO ltr Op-26 A19 Ser 1517P26 of 21 Nov to BUORD

1. The coordination of the work being done by the Naval Observatory on Bureau of Ordnance Project No. 16733 and Ohio State University, under Air Force contract, is satisfactory as outlined in reference (a). It is believed that mutual benefit may result by direct cooperation.

2. The Naval Observatory is hereby authorized to exchange reports with the Ohio State University and provide such assistance as may be practicable and mutually agreeable. It is requested that the Bureau of Ordnance be kept informed of results of this mutual effort by copies of correspondence or such informal reports as may be of interest.

3. Dr. J. A. Hynek, director of the Air Force project at Ohio State University, is informed of this action by copy of this letter and requested to furnish the Bureau of Ordnance, Department of the Navy, Washington 25, D. C., Attention Re9a, with a copy of reports or results of this study as they become available, in addition to those furnished the U. S. Naval Observatory.

M. F. SCHOEFFEL

Copy to:
OHIO STATE UNIV Columbus
(Dr. J.A. Hynek)

E. C. SLIDER
By direction

PLANS FOR THE FUTURE

The construction of the photometer should be completed during the next report period, and its testing in the laboratory and on the telescope should be well advanced.

Preliminary observations of very small areas of blue sky are also expected to have been made by the close of the next report period (March 31, 1952).

The literature survey is expected to be completed and the critical report based on this to be well advanced if not completed.

PERSONNEL AND ADMINISTRATIVE MATTERS

Personnel

The design and construction of the photometer was under the direction of Dr. Geoffrey Keeler and Dr. Charles Shaw, with Mr. Frotheroe in charge of the electronic recording components. The critical survey of the literature is under the direction of Dr. J. A. Hynek, with Mr. Roger Mosfeld as the chief library research worker.

Fiscal Information

(1) The fiscal balance as of Dec. 31, 1951 was $23,011.76. The expenditures during this initial period were abnormally small because the project was in the planning and design stage.

(2) We expect to purchase a Brush two-pen recorder and double amplifier, a wave analyzer, a suitable tape recorder and perhaps a sonograph. Procurement of the latter item is still highly tentative.

(3) Unassembled electronic and photometer parts are to be procured.

NOTE: In submitting this report it is understood that all provisions of the contract between The Foundation and the Cooperator and pertaining to publicity of subject matter will be rigidly observed.

Investigator ..... Date .....

Supervisor J. Allen Hynek Date Mar. 22, 1952

For The Ohio State University Research Foundation

Executive Director Oram C. Wolfert Date 24 March 1952
O.R.F.

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AIR FORCE RESEARCH LABORATORY (AFMC)

MAR 15 2000

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SUBJECT: Distribution Statement Change

1. The following documents have been reviewed and it has been determined that the distribution statement is no longer appropriate. The documents are Progress Reports 1 through 8 under Contract No. AF19(604)-41, Ohio State University Research Foundation, Columbus, OH.

a. Document No.: AD 000014
Title: Fluctuations of Starlight and Skylight
Date: 15 Mar 1952
Classification: Unclassified

b. ~~Document No.: AD 000027~~
~~Title: Fluctuations of Starlight and Skylight~~
~~Date: 15 Apr 1952~~
~~Classification: Unclassified~~

c. Document No.: AD 000066
Title: Fluctuations of Starlight and Skylight
Date: 25 Jul 1952
Classification: Unclassified

d. Document No.: AD 005282
Title: Fluctuations of Starlight and Skylight
Date: 1 Nov 1952
Classification: Unclassified

e. Document No.: AD 010919
Title: Fluctuations of Starlight and Skylight
Date: 24 Feb 1953
Classification: Unclassified

f. Document No.: AD 021921
Title: Fluctuations of Starlight and Skylight
Date: 15 May 1953
Classification: Unclassified

g. Document No.: AD 021922
Title: Fluctuations of Starlight and Skylight
Date: 25 Jul 1953
Classification: Unclassified

h. Document No.: AD027024
Title: Fluctuations of Starlight and Skylight
Date: 23 Nov 1953
Classification: Unclassified

2. Request these documents be assigned Distribution "A" Statement. These documents have been reviewed and cleared for public release by ESC/PA.

3. This action is in response to FOIA 2000-33.

Noreen Dimond

NOREEN DIMOND
STINFO OFFICER

8 Attachments:
1. Rpt #1 (cover) (ESC 00-0346)
2. Rpt #2 (cover) (ESC 00-0347)
3. Rpt #3 (cover) (ESC 00-0348)
4. Rpt #4 (cover) (ESC 00-0349)
5. Rpt #5 (cover) (ESC 00-0350)
6. Rpt #6 (cover) (ESC 00-0351)
7. Rpt #7 (cover) (ESC 00-0352)
8. Rpt #8 (cover) (ESC 00-0353)

cc: AFRL/VSIL w/o atchs
AFRL/VSIP w/o atchs

Received 3-22-2000
Completed 5-18-2000