A A V S O   A B S T R A C T S

Edited by R. Newton Mayall

PAPERS PRESENTED AT THE 45TH SPRING MEETING, MAY 18-20, 1956

Once again AAVSO members and friends invaded the campus life of a great University. This spring, through the kind invitation of Dr. R. William Shaw, Chairman of the Department of Astronomy of Cornell University, the council and other members arrived in Ithaca, New York, on the afternoon of May 18, 1956. Here,too, is the home of our ex-president, Dr. Martha Stahr Carpenter, who together with Dr. and Mrs. Shaw, made our visit a most enjoyable one. Spring is late this year, in Northern latitudes, but that did not detract from the beauty of the surrounding countryside. Ithaca lies at the southerly end of Lake Cayuga, in the heart of the Finger Lakes region of New York State. Within a few miles of the campus are numerous gorges alive with running water and thundering waterfalls, some of which are as high as or higher than Niagara.

Friday evening, Dr. Shaw brought the official greetings and talked to us about interplanetary travel. This was followed by a pleasant social hour and collation, which had as a feature the Russell diagram, made of cookies with colored frosting.

Saturday morning proved that AAVSO'ers are interested in things other than just astronomy, for a goodly number got up at 0600 to take a bird walk in a nearby sanctuary. This was led by Dr. A. A. Allen, whose famous recordings of bird calls are known throughout the world. The group saw more than 65 different species of birds. We are grateful to those who arranged this interesting digression. In the afternoon Mrs. Shaw arranged a tour of the buildings and museums for the ladies. From all reports, it was a most enjoyable trip.

Our morning and afternoon sessions were full of interesting papers, and the editor is grateful for the cooperation of the members. Copies of almost all of the papers were in his hands before the meeting. This is saving a lot of time, and you will receive the Abstracts earlier than usual.

Our dinner was held Saturday evening, at the Cornell Heights Residential Club, where sobriety and sociability were the order of the day. After a most satisfying meal we visited the observatory and had a good look at the moon through the 12'' refractor. This was followed by a visit to the Ionospheric Laboratory, after which we returned to the Residential Club, where Dr. Jesse Carpenter showed us many beautiful kodachromes he and Mrs. Carpenter took during their year in Australia. Their slides gave a vivid picture of this vast, fascinating, and fabulous continent, which is as large as the continental U.S.A. Our only regret was that Mrs. Carpenter could not be there to enjoy them with us, but shortly before the meeting she became ill and was confined to the house. Newton Mayall showed a few kodachromes of Iceland. Clint Ford projected his movies taken at the Pittsburgh and Springfield meetings in 1955. Bob Dunn presented a short film of the Springfield meeting. These candid shots of what goes on are always welcome.

Sunday morning we visited the Radio Astronomy Laboratory and Dr. Gartlein's Auroral Laboratory.

We were most happy to have Prof. Boothroyd with us. He has been a faithful member of long standing. Also it was pleasant to greet the Goods, Morgans, De Kinder, the Misses Williamson and Clark, and Mrs. Yane from Montreal, Canada.

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INTERPLANETARY TRAVEL AND THE NEW ASTRONOMY, by R. William Shaw

Interplanetary travel is no longer a comic book item. The sun is the dominating factor in our system. In order to get off the sun a speed of 383 miles per second will be needed; off the earth, about 7 miles per second; off Jupiter, about 37 mps. There are several ways to get off: a single blast like the firecracker rocket; by stages of blasts; but if man is to travel he must go slowly and easily by a continuous source of energy. The three-stage system is being used for the artificial satellite. Astronomy has done its job. Now it is up to the engineers and the taxpayer.

What can be accomplished? Can an artificial satellite get up there? If so, where is it? Amateurs will play a great part. After the batteries have run down, it will have to be observed with telescopes to follow and photograph it. A large number of observers will be needed to scan the sky. Once it is discovered, we can trigger a device by radio, to receive data from it. Therefore information as to its position is important.

Some of the information we hope to get from the artificial satellite includes: atmospheric density; accurate measurements of the earth's equatorial diameter and its oblateness; additional data about ultra-violet light from the sun; cosmic radiation; density of hydrogen ions; Stürmer current ring; earth's crust and distribution of mass. The earth satellite is the first step to progress.

If the satellite is successful the manned rocket will be the next step, with either a manned satellite or interplanetary travel the goal. Within the solar system visits to nearby objects may help us clear up such problems as the origin of the craters of the moon, features of Mars, etc. The big astronomical problem of the solar system is its origin. Near approach or contact with asteroids and comets may provide essential information on this question. Observations of binary stars from either a platform or the moon will give us more exact data for the improvement of the Mass-Luminosity relation. Observations from a satellite, say of Jupiter, would vastly improve parallaxes and our fundamental distance relations.

Outside our atmosphere spectroscopy would, through the now veiled ultra-violet and infra-red, increase our knowledge of stellar structure many fold. The study of dark matter, such as the Horsehead nebula, would be facilitated since many molecules and most solid matter have characteristic vibrations in the infra-red. Since skylight would be almost negligible, the photography and spectroscopic analysis of faint extragalactic systems would be possible on an unprecedented scale. Perhaps the question of the actual extent of our universe might finally be solved.

LONG PERIOD VARIABLES IN THE SCUTUM CLOUD, by Margaret Harwood

This is a further report on the photographic study of variables in the Scutum Cloud that were discovered at the Maria Mitchell Observatory, Nantucket, Mass. The light curves of certain long period variables in the Scutum Cloud have been found to bear remarkable similarity to brighter variables of similar periods as shown in the Leon Campbell Memorial Volume. For example:

CH Scuti, 184708, P = 191^d, 14.5 - (17.7, similar to RT Cygni
157 Scuti, 184908, P = 153^d, 14.2 - (17.0, broad max and pointed min like Y Oph.
AI Aquilae, 185507, P = 103^d, 13.5 - 15.1, sine curve variation like SS Herculis.

COLOURS IN SUNSPOTS, by Francis P. Morgan

During the year of 1946-47, the writer made a regular series of observations of sunspots, using a 6-inch refractor, projection method. Two basic colours, purple and yellow,always seem to predominate and follow a certain pattern. Under average conditions, the umbrae are a deep purple, the penumbrae a much lighter shade of purple. Sometimes a yellowish tint is present on the general surface, extending outwards from the penumbral border and fading out over the surface without any sharply defined border. Under ordinary seeing conditions, where the penumbrae cannot be resolved,the diffuse yellows can only be seen when they appear beyond the penumbrae onto the general surface or between the umbrae of large spots.

Spurious colours due to refraction are easily distinguished from true colours,because one side of a spot will appear blue or green and the other side green or orange, and the same effects will be seen on the limb. When I observe the sun with my 6-inch reflector or with other telescopes, the colours are less pronounced than with refractors.

VISUAL METEOR OBSERVING FOR THE IGY, by Peter M. Millman

During the IGY the National Research Council of Canada is planning to have continuous radar recording of meteors, 24 hours a day. There are many other programs which are designed wholly for professionals; but in addition there are several ways in which the amateur can make valuable contributions to the work of the professional meteor observer. Some of the things amateurs can do that will be of value are as follows: Group counts, where several persons can be so arranged as to cover the entire sky at one time; magnitude (apparent visual magnitude) estimates made to the nearest half magnitude; on the spot estimate as to whether meteors observed are a part of a shower and its name; and observing on non-shower periods. Visual plots and heights are not needed as much as they used to be.

THE SKIES THROUGH A PRISM, by Frank J. Kelly

During recent years, a great deal of effort has been made to add to the comfort of the observer. A good example is that of the Springfield Mount which allows the observer to sit comfortably in one position while his telescope swings to all points of the sky. The most recent of all telescopes rests on a table top.

There are available excellent zenith prisms, but a recent turret-like model facilitates adjustment of the power of the eyepiece. When using this prism, no amount of chart orientation will show the observer a picture of what he is actually seeing. The chart could be turned over and a light allowed to shine through it, but it is a rather cumbersome arrangement. One could hold the sketch up to the light and copy it from the back of the sheet, but with some loss of accuracy. A lefthanded image is not acceptable.

It would be a monumental task to print a large number of reversed Variable Star Charts and then re-number the magnitudes in their proper order. But if the chart negatives were reversed and reprinted without regard for reversed letters and numerals, the zenith prism would become useful in tracking the path of the variable star and it takes very little training of the eye to acquire accuracy in reading reversed numerals. I believe that the small loss of light caused by reflection would be compensated by the relaxed condition of the eye and more accurate estimates would result

TOP-SECRET PLANS FROM THE INNER SANCTUM, by Clinton B. Ford

The Inner Sanctum is a voluntary, mysterious, group of observers within the AAVSO who have made, begged, bought, borrowed or stolen telescopes of sufficient size so that they can sneak in observations fainter than 14.0 magnitude, thereby being able to catch an unwary minimum of an elusive and important light curve. The top-secret plan is the comparison of results among members of the Inner Sanctum, for which purpose I have made a standard form, for the private use of the Inner Sanctum. This form can be circulated among the members of I.S. and entries made as it goes the rounds.

AURORAL WORK FOR THE IGY, by Carl W. Gartlein

The auroral program for the IGY includes the photometry of airglow; the use of the Meinel spectroscope; the use of scanning spectrographs with exposure controlled electrically; a chain of radar stations, principally in Alaska; visual observations; and a synoptic program to make a map of the world showing distribution of aurorae over the world on 15-minute epochs -- about 12 "all sky" cameras will be required to cover the U.S.A. (Dr. Gartlein provided the members with copies of literature describing "Proposed Methods of Visual Observation," "Description of Auroral Forms," and a "Punch Card Reporting of Auroras." Ed.)

COMPARATIVE ADVANTAGES OF A DOMED OBSERVATORY, by Frank De Kinder

The observation of the sun with a telescope set out in the open involves exposure to the wind which shakes the instrument, and loss of time waiting for temperature equalization. The permanent domed observatory, however, has the drawback of the heating of the dome by the rays of the sun, creating upward waving of the air which is fatal to excellent images, even if the aeration of the observatory is such that there is little difference between the inside and outside temperatures.

The great advantage of observatory observations is,of course, the permanence of the installation where an observation can be made in a minimum of time -- especially in the projection method of observation of the sun, which in my opinion is superior to visual observation in that it reveals at once the heliographic coordinates of the disk, and facilitates the exact location of the different groups. The observatory is by far superior in that it also eliminates the work of mounting and dismounting the screen.

REJECTION OF SOLAR OBSERVATIONS, by Frank De Kinder

For a long time I have been at variance with the system whereby solar observations are rejected when cloudiness of the sky is more than 5. What is important is the quality of the image. Provided during the moments of observation the sun can be seen clearly, what does it matter how much cloud there is elsewhere in the sky? If clouds cover the sun, no observation is possible, but if the sun is at all visible, no observation should be rejected. Even if the sky is hazy or milky, a satisfactory observation is possible. It should be left to the individual observer to qualify his observation as E, G, F, or P; and the computer should reject only the P ones, if sufficient observations of a better quality are available for the day.

PREDICTION OF NEXT SUNSPOT MAXIMUM, by Leith Holloway

It appears that the next maximum of $\bar{R}_A$' will be about 196 at 1957.25. Waldemeier predicts a maximum of about 170 at 1957.1. (Bondy pointed out that the paper was written 4 months ago, and since then sunspot activity has been going according to predictions. More details of this will appear in the Solar Division Bulletin. Ed.)

THE ANNULAR GROUP, A SOLAR ODDITY, by James G. Bartlett, Jr.

A brief survey of ring formations yields the following facts: 1) Ring types are very rare in relation to all other types of spot organization; 2) Ring types are of very short duration, the majority disappearing in less than a day; 3) Ring types may form distinct groups, but the majority arise as sub-groups within any given type of ordinary group; 4) Ring types show a decided preference for the half-circle over the complete ring; 5) Ring types, whether as distinct groups or as sub-groups, are mostly small -- a fact which may be related to their short lives; 6) Ring types, when occurring as sub-groups, show no preference for any particular type of host group; 7) Ring types are apparently abnormal manifestations of the ordinary spot-producing forces -- whatever those forces may be.

PRESENT PHASE OF SOLAR ACTIVITY, by Harry L. Bondy

Right now we are witnessing a most unusual rise to sunspot activity, which is steeper and faster than ever before. Groups that change rapidly have the greatest flare activity. (More detailed supporting data is to be included in the Solar Division Bulletin. Ed.)

A SOLAR FLARE INDICATOR, by David D. Warshaw

This instrument tells me when there is a solar flare, so that I can observe it with my polarizing monochromator. It tells me when short-wave communication will "fade out;" and it even forecasts magnetic and ionospheric storms and auroras, 26 hours in advance! The "S.E.A." (Sudden Enhancement of Atmospherics) method makes it possible to fix, within narrow limits, the times of beginning and maximum of a flare. It would, therefore, be of great value to solar research if a number of these receivers could be in operation in both America and Japan, in time for the IGY 1957-58.

My "solar flare indicator" can be constructed easily, at a very small cost, by anyone interested in this fascinating work. If a number of these instruments could be well distributed in longitude, no major flare should pass undetected for lack of direct observation. My receiver contains three transistors, two flashlight batteries, four small coils, and three or four small condensers and resistors, in a metal box measuring only 3" x4" x5". (Complete details for constructing this instrument will be published in a future issue of Radio Electronics Magazine, and details will appear in the Solar Division Bulletin. Ed.)

EVOLUTION OF SUNSPOTS, by Thomas A. Cragg

(Harry Bondy described the beautiful drawings sent by Thomas Cragg showing sunspots in January and February 1956. Beside them were photos by Hans Arber and sketches by Georges Emond showing the same spots. Their agreement was quite striking. Ed.)

RADIO ASTRONOMY AT CORNELL UNIVERSITY, by Edward R. Schiffmacher

Our work in radio astronomy is devoted almost entirely to solar studies at present. An antenna which tracks the sun throughout the day records the total power level of solar radiation at a frequency of 200 mc/sec. Continuous recordings of the receiver output are made, and from accurately located timing marks, the times of any outstanding occurrences can be determined. Through a cooperative program with the McMath-Hulbert Observatory, studies of the correlation of optically observed events with those observed in the radio spectrum are carried out.

A radio interferometer, also operating on 200 mc/sec (a wavelength of 1.5 meters), permits the sources of enhanced radiation to be located on the sun's disk. This instrument consists of two antennas spaced approximately 50 wavelengths apart along an East-West line. The characteristics of the individual antennas permit observations to be made covering a period of about an hour each side of local noon each day.

Other programs in progress at the Radio Astronomy Observatory include: the development of a 3600 mc/sec solar radio telescope using a fixed parabolic antenna and a movable plane reflector after the fashion of a heliostat. A 17-foot parabolic antenna, constructed in 1948-49 in connection with the solar studies then in progress, is now being fitted out for use as a 200 mc/sec polarimeter, with associated equipment designed to permit observation of two circularly polarized components of solar radiation simultaneously and with variable receiver bandwidth; a program studying microwave propagation over long distances by means of a tropospheric scattering mechanism. Other projects which have been undertaken at this observatory since the start of radio astronomy research at Cornell in 1946 have included several short-term investigations involving the sun, and also several experiments in which the sun was not involved, such as: measurements of the distribution of radiation received from the Galaxy at 200 mc/sec permitted an accurate determination of the radio plane of the Galaxy to be made.

An occultation of a radio star in the constellation Taurus by the solar corona was the object of theoretical study in an effort to explain observations made on several frequencies by workers here and elsewhere; and more recently, a variable-spacing swept-lobe interferometer was used to determine the brightness distribution across the quiet sun at 200 mc/sec.

WHAT GOES ON! by R. Newton Mayall

In 1950 less than 500 stars were actively observed by the AAVSO. Today there are about 800 stars on the list. A critical analysis of all activities began in 1950. Due to the excessive cost, the use of IBM cards and machines was ruled out, and the "linedex" system adopted, which greatly reduces the time and labor in processing observations and their subsequent publication. New forms have been designed for all phases of the work. Standardization has saved time and space. All information about a single star can now be found in one folder, in contrast to such information being scattered in three, four, and even five different places, prior to 1950.

Since 1950 great strides have been made in organization and efficiency. The same personnel is now doing more than double the work done prior to 1950. Normal every-day methods of efficiency in business have been incorporated as rapidly and when-ever possible. If the observer wonders why things get behind at times, just remember this one fact, which is just a fraction of the work that has to be done and is done: a study showed that it takes one person at least 34 weeks or almost eight months of solid work every day to just plot, type, and sort the observations received at headquarters.

Headquarters is a storehouse for a vast amount of material. The present stature of the AAVSO, its ability to continually add to its program, provide special services, and numerous other activities is due to a continuing critical analysis of its various operations and the reorganization that has taken place.

The AAVSO has a bright future, and its program and worth will be even greater.

A PECULIAR AURORA IN 1941, by Gunnar O. Darsenius

On September 20-21, 1941, many peculiar aurorae were seen over Scandinavia. Pulsating arcs and patches appeared over all the sky. In the evening, on September 22, I looked at the sky in hope to see an aurora but the sky was dark, including the northern sky. But very soon after that I saw in the eastern sky a bright cloud, which disappeared after 10 seconds. Twenty seconds later it brightened and disappeared again; and then it continued to appear and disappear during many hours, sometimes regularly, sometimes remaining bright several minutes. It didn't move from its place on the sky during the time I saw it. No other auroral activity was seen. This isolated, pulsating patch was also observed by Dr. A.V.Nielsen, in Aarhus, Denmark. Prof. Carl Störmer in Oslo had two photographic stations in action and he found that the patch was situated above the sound between the two islands of Oland and Gotland in the Baltic Sea, at a height of 110-112 kilometers.

ARE MARTIAN CANALS REAL? by Paul L. Gernant

The excitement stirred up by Schiaparelli and others in 1877 when the canals were first seen has steadily decreased. Still, the possibility of some form of life on Mars, suggested by the canals, is a very interesting proposition.

Those who believe that the canals do exist claim that since they have seen the canals they are definitely real. The opponents accuse them of eye-strain due to attempting to see detail at the extreme limit of visibility. However, Schiaparelli could hardly be accused of this since he certainly was not looking for any canals. Therefore I think it is safe to assume that he actually saw the canals.

Later Percival Lowell conjectured that the Martians had built a geometric array of canals to bring water down from the poles to irrigate the land.

I think that the aperture of the telescope is a decided factor in seeing the canals. This is based on the fact that Schiaparelli and Lowell used telescopes of relatively small aperture, while many present astronomers using the world's greatest "eyes" have been unable to get a glimpse of the canals. This may be due to the fact that the larger telescopes "resolve" the canals and show them as several scattered markings, while the smaller telescopes run the markings together, thereby forming a continuous line. If this is true it is probably possible to see the so-called canals with a common six or eight inch reflector. Not until we get good photographs of the canals of Mars will this argument be settled.

VALUE AND USES OF PLANETARIUMS, by George Lovi

About a generation ago, a new medium was introduced to reproduce the wonders of the heavens in such a way that it can be brought indoors and shown to an audience of many people at a single showing. This device, which has proved very efficient, is known as the projection planetarium. Since its inception in the early '20s it has proved very popular with audiences of every type. The first planetarium was produced by the firm of Carl Zeiss in Jena, Germany, to present the fascinating and ever-changing sky story. At present there are about 14 large Zeiss instruments in active operation throughout the world, including 6 major planetaria in the United States. The instrument is geared to produce the sky-picture as it appears at any given moment. With only slight error, it can reproduce the sky as it appeared thousands of years ago and how it will appear thousands of years hence. This is possible through its ecliptic axis. The entire machine can rotate in precession.

Since the war, Armand Spitz designed a much smaller planetarium called "Model A Spitz Planetarium." The first of these instruments were relatively crude, but today his small planetarium is a marvelous little instrument. It is widely distributed throughout the world, especially in museums and educational institutions. Mr.Spitz also developed a large planetarium projector which he calls "The Spitz Model B." Planetariums are an excellent device to stimulate an interest in astronomy.

PREDICTED AND OBSERVED LIGHT CURVES, by Margaret W. Mayall

In late 1952, it was suggested to me that it would be a useful aid to spectroscopists and others interested in planning programs involving long period variables, if I would use AAVSO observations to draw up predicted light curves for the next five years. As a test, I started with a group of nine of the brighter long period variable stars. Now that we have somewhat more than three years of observed curves for these stars, it seemed worthwhile to make a study of the observed deviations from the predictions.

Some of the predicted curves were drawn with alternating high and low maxima, when the observations of the previous years seemed to indicate such variations. A comparison of the observations with the predicted curves indicates that if predictions are to be used to show deviations of the observed curves from the mean, it would be better to have the predicted curves traced from the mean curves, with no indication of varying heights of maxima. The deviations show the necessity of continuous observation of all these stars.

PICKING A NOVA FIELD AND OBSERVING IT, by George Diedrich

In picking out an area you will need Instruction Sheet #4, some sort of star chart or atlas of the skies and a list of the areas already being observed, in order to prevent duplication. We still have more areas than observers and we ought to try to cover the Milky Way completely before overlapping our areas. We leave it up to you to pick out two areas about 12 hours apart. Instruction Sheet #1 gives complete details as to how to pick a nova search area and how to observe it. Patience, of course, is required, for night after night no positive results will be obtained; that is, novae are rare beasts. However, it must be remembered that it is important to know the magnitude observed and to know that no nova of that magnitude occurred in some part or all of the sky, and for how many nights we could say this. All observations, questions, comments, etc., should be addressed directly to George Diedrich, 653 Weller Road, Elyria, Ohio.

WHY NOT TRY METEOR PHOTOGRAPHY, by Edward Majden

During the last Perseid and Geminid showers successful photographic meteor observations were carried out by members of the Regina Astronomical Society. The Perseid observations were carried on over a period of three evenings in conjunction with a visual group. Over this period, one spectrum and two direct meteor photographs were taken, of which one was a direct photograph of the spectrum. During the Geminid shower, one camera was exposed for 156 minutes, which resulted in one direct meteor photograph. Results were sent to Dr. Peter M. Millman, National Research Council, Ottawa, Ontario.

I feel that more amateurs should participate in this field of astronomy; particularly AAVSO observers because of the experience in magnitude estimation. All one requires to do this work is a good camera, (F-4.5 or so, with a 4 to 10 inch focal length), sturdy mount, record book, and most of all, a lot of patience.

For spectrographic work a 30° prism should be attached to the camera. Pick a date for your photography near or on the date of maximum of the major showers. Be sure to keep a good record of the sky conditions, exposure times, meteors crossing the field, etc. One should try to do photography in conjunction with the visual group. The best position to point your camera is near the radiant.

NEW SOLAR LABORATORY FOR NORTHWESTERN OBSERVATORY, by Ben C. Parmenter

The new instrument will replace the older and obsolete tower telescope arrangement. This new instrumentation will incorporate many of the finer points of construction at other solar observatories such as at McMath-Hulbert. A Foucault heliostat will send the sun's parallel rays to a 15 cm Pyrex concave mirror of 8.4 meters focal length. The returning off-axis beam will then enter a port on the south face of the observer's chamber, and cause a 7.5 cm image to be formed upon the 30-inch face plate of the spectrograph. Here, light from either the limb, or other selected areas of the solar disk will by-pass the entrance slit, run horizontally down the building's length to a 7.5 cm collimating mirror some 4 meters distant.

This powerful apparatus will be used daily to study the chromospheric arc of the Sun's limb in Hydrogen Alpha, Hydrogen Beta, and Helium, as well as Calcium values. Also, spotted areas of the solar-disk which at times may visually show coloration are to be closely studied, in an effort to determine their origin. Reports of these will be made known to High Altitude Observatory, Boulder, Colorado, as in the past.

SOME IDEAS CONCERNING THE EXPANDING UNIVERSE, by William Raine

Spectra of the distant galaxies have a decided red-shift, which is more prominent in more distant ones. Many astronomers concluded that red-shift was proportional to distance.

The greatest speed yet found for these galaxies is 38,000 miles per second, which is about one-fifth that of light. But suppose there are galaxies travelling even faster. Let us look at the equation for the Doppler effect:

$$\frac{\text{Change of wave-length}}{\text{Normal wave-length}} = \frac{\text{speed of source}}{\text{speed of light}}$$

If we substitute 5000A for normal wave-length and boost the speed of an imaginary galaxy to 3/5 that of light, we get a change of 3000A. The line is then found at 8000A in the infrared. If such galaxies exist and the above theory is correct, it is doubtful that they will ever be found because of their extreme distance, even though special photography is used to detect their infrared light

Certain kinds of interstellar matter absorb violet light and could be responsible for dimming these galaxies to the point where they might be thought very distant. It is possible that this absorption of violet light could produce a red-shift.

If upon finding the distances and velocities of galaxies from all parts of the sky, a group in one part is found to be relatively close and having a relatively slow velocity, and a group in the opposite direction to have a great distance and velocity, we may assume the center of the universe to lie in the direction of those most distant galaxies.

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