The One World of Stars

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THE 6TH PRESIDENT OF THE UNITED STATES is accredited with the rather astonishing statement that one can judge the state of culture in a nation by the condition of its astronomical observatories. I trust that he meant that the better the astronomical situation, the higher the culture. It would be most distressing if he meant that when astronomers prosper, culture declines.

John Quincy Adams, who after persistent effort incited his Harvard College to undertake the first ambitious development of astronomical research in America, was succeeded in the White House by men whose devotion to culture did not include active promotion of national efforts to take care of the stars. Their interests were earthy, planetary in scope, or even merely continental. But the 32nd president (Franklin Roosevelt) took an important part in celebrating the quadricentennial of Copernicus, who was the father of modern sciences as well as the promulgator of the heliocentric theory of the solar system. Privately F.D.R. expressed whimsically a lack of sympathy for Copernicus—"He looked through the right end of the telescope, thus magnifying his problems. I use the wrong end of the telescope and it makes things much easier." Tonight the White House, through a distinguished representative, has again joined in a program involving stars and telescopes.

Stars and governments have long been associated. In ancient times the rulers made use of the charlatan astrologers to guide their acts and justify their sins. We now use professors in that role, and investment bankers. The Babylonian, Egyptian, Chaldean, Greek, and Roman cultures supported through their governments astronomical instrumentation and interpretation—sometimes with philosophers, sometimes with star-measuring devices.

But the modern association of government and astronomy is more significant. The great Royal Observatory in Greenwich was founded by Charles II; the Russian observatory in Pulkowa, which until its destruction in the recent World War held a dominant place in European astronomy, was founded by Czar Nicholas I; Germany's famous observatory at Potsdam was created at the request of the Crown Prince who became Kaiser Friedrich; the Vatican Observatory, located at the Pope's summer residence, is one of the most important of the European astronomical institutions; President Avila Camacho personally subsidized and inaugurated the new astrophysical observatory at Tonanzintla, Puebla, where the largest telescope bears his name; and President John Quincy Adams took an outstanding part a century ago not only in the founding of the Harvard Observatory but in the dedication of the people's observatory at Cincinnati.

I cannot fully explain why heads of governments in these notable instances have been so keen on astronomical exploration—why they have been friendly and promotive of that most "useless" of human enterprises: only in small part, I would say, because of its association with navigation and almanacs; only in part because of the prestige of its erudite aloofness; and only in part because of the noncontroversial nature of celestial mechanics. Perhaps our primitive ancestors, who were not bothered by mazdas and neon and were therefore in closer contact with the stars, had accumulated over the centuries and millennia so much curiosity concerning those untouchables that we continue to discharge the inherited responsibility of satisfying that curiosity about heavenly bodies. But these explanations are not complete. I remain surprised and also, quite naturally, pleased that astronomy, along with some of the other sciences, is able to maintain good international relations when economic, religious, and diplomatic intercourse is so very difficult.

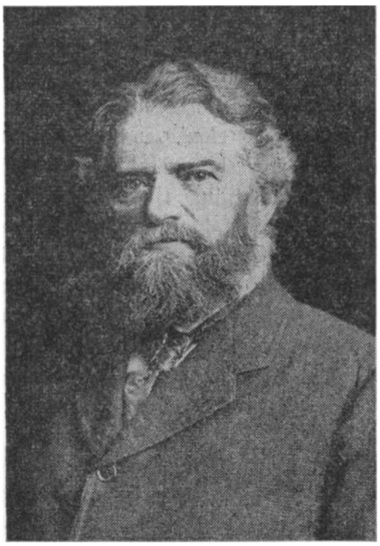
In 1941, when American-Mexican relations were strained by the confiscation of oil-producing properties and also by politics and by the church-in-education policies below the Rio Grande, the government of Mexico invited 30 American astronomers to hold a convention in Mexico and participate in the inauguration of a new observatory. This astronomical gambit was followed in succeeding years by expeditions into Mexico (under Mexican government auspices and expense) of physicists, chemists, and mathematicians.

The first postwar technical scientific congress was held in 1946 by the Russian, Scandinavian, English, American, French, Vatican, Dutch, Belgian, and other astronomers. Was the conference permitted by suspicious governments because astronomers are harmless, or because they are convincingly devoted to nonnationalism in science? Nine Russian astronomers spent many months in America in 1947, visiting all the American observatories and taking part in conferences. Last month the USSR Academy of Sciences

Address of the retiring president, AAAS, delivered on the evening of September 13 in Constitution Hall, Washington, D. C., during the Association's Centennial Celebration.

invited the International Astronomical Union to hold its next worldwide conference in Leningrad—an invitation that was of course welcomed, because a score of Russian astronomers are on the International Astronomical Commissions and one of them is vice-president of our international scientific union. Eight Russians and several from Finland, Poland, Czechoslovakia, Austria, and Hungary attended this summer's meetings in Switzerland of astronomers from 30 countries. Apparently the sun, moon, and stars ride high above the nation-separating curtains.

To some extent also in meteorology, agriculture, geodesy, and special branches of medicine has the famous curtain been permeable during the past year or so. It is a net, which tangles operations somewhat, but with patience and persistence the obstructions set up by politicians and the agencies of statesmen are by-passed or overflown, and the natural two-way traffic in goodwill and cooperation continues.



Simon Newcomb, the 24th president of the American Association for the Advancement of Science.

The "One World of Stars" is a reality, and its significance should not be ignored in other fields of science and art, and, in fact, one-worldness need not be confined to the cultural fields. The stars are supranational, as also are the laws of gravitation, genetics, radiation, nutrition. Cannot goodwill, human brotherhood, and a common ambition for the higher cultures also develop as boundary passers? Our series of evening lectures this week are aimed to illustrate for many fields the one-worldness of science. No more hopeful and constructive theme could be found to celebrate this 100th anniversary of our Association.

I shall proceed by discussing the internationalism of some major astronomical adventures and show that international collaboration is essential for the progress of our science, and in these nervous days doubly important for the progress of international amity.

The 24th president of our Association for the Advancement of Science was Simon Newcomb. Somewhat incidentally he was a novelist, an economist, and a government official, but primarily he was a mathematical astronomer and one of the greatest of American scientists of the 19th Century. One of his early studies concerned the positions and motions of the sun, moon, and planets. He sought to bring order out of the chaos resulting from much uncoordinated measurement, in the many national observatories. Jupiter and Saturn are rather obstreperous in the way they push and pull around the smaller planets, ours included. But by using all the old and modern measures of their positions, Newcomb and his assistants, after cleaning the observations properly, could develop theories to predict accurately what would happen in the years to come.

It is definitely an international job—this refined study of planetary motions—and in 1871 we find Newcomb in Germany looking up the old records and then in France digging into the century-old archives for the observations made by gone and forgotten observers. At the Paris Observatory he worked diligently on the stars and planets that are the property of all nations and remained essentially oblivious to the cannonading which the French were then using to settle a political question.

Going further back, we recall that in 1780 the British military governor of the Penobscot Bay area gave permission to the representatives of the American Academy of Arts and Sciences and of Harvard University to go to the Maine coast for the observation of a total eclipse of the sun. Although the Americans and British were busy with the Revolutionary War, this astronomical enterprise seemed to be sufficiently worthy, and arrangements for the trip were easily made. The available maps, by the way, were faulty, and the observers missed the totality by locating at the south edge of the path. But the expedition was not a failure. In a nice demonstration of serendipity, the astronomers, through this accident, observed something more interesting than the solar corona which they journeyed to see. The Rev. Mr. Samuel Williams, the Harvard professor of natural philosophy, saw for the first time and described the brilliant beads of light which frequently appear just as an eclipse is beginning or ending its total phase. These bright flares are the result of sunlight pouring through the deep mountain valleys on the moon. The eclipse beads of Revolutionary War time were described again 50 years later by an Englishman and are now unfairly known by his name. They are Baily's beads, not Williams' beads, as they should be in the name of justice. But astronomers are not inclined to make an international incident of the matter. They are not asking His Majesty's Government whom the devil they think they are pushing around.

In fact, astronomers and other scientists are not natural warmakers. The real fight is against unknowns, not against neighbors. Scientists' problems are world problems. The laws of physics and biology are universal. There is no place for selfish nationalism in astronomy or medicine, in mathematics or meteorology. What one scientist discovers is the property of the world of science and the world of all men.[1]

There is another well-known illustration that science and man's interest in science transcend war hatreds and work to decrease national prejudices. During his great travels of scientific discovery in the late 18th Century, the famous English navigator, Capt. James Cook, was protected by order of the American government, through the agency of Benjamin Franklin, from the American privateers that roamed the ocean and harassed British shipping.

During our recent World War the astronomers kept up a sort of impersonal contact across or around the battle lines. I remember, for instance, that a Russian astronomer at his observatory south of the Caucasus on the Turkish frontier in Asia discovered a new comet. The German armies were overrunning western Russia, and terrible battles were in progress in the northern Caucasus. The discovery was radioed across the battle lines to Moscow, and Moscow found time and interest to radio it directly to the Harvard Observatory for further telegraphic distribution.

Also during the war, in Rumania, which was an ally of Germany at the time, a comet was discovered and reported to the Royal Astronomer in Bucharest, who reported it to the Royal Astronomer in Denmark, who transmitted it to the Chief Astronomer in Switzerland, who forwarded it to America. The U. S. Navy, by the way, checked up on this Rumanian comet rather carefully to see if it were subversive.

Not only in reporting astronomical events, but in prolonged researches, astronomers continue to demonstrate the One World of Stars. There is a striking recent story of cooperation that should be recorded, namely, the new and most accurate measurement of the distance from the earth to the sun—the solar parallax. This distance is the so-called "astronomical unit" of approximately 93,000,000 miles. It is a fundamental unit of measurement throughout the extraterrestrial universe. The ancient Greeks tried to estimate the distance and during the 18th and 19th Centuries much attention was given to the various ways, direct and indirect, of finding the solar parallax. The direct measures of the sun from this little planet of ours are clumsy; but since through gravitational principles all the distances between all the bodies in the solar system are linked together, it has been found best to operate indirectly and to measure the distance to the planets and deduce from them the solar distance. A small, rapidly moving planet has advantages, and therefore much attention has turned, since its discovery half a century ago, to the minor planet Eros, which is periodically brought, in its somewhat elongated orbit, very near to the earth. The sharpness of its image on the photographic plate permits a precision that is impossible in measuring objects of large angular diameter like the sun and moon. About 18 miles in diameter, this asteroid Eros is not ordinary. Most of the 1,500 tabulated minor planets stay on their reservation between the orbits of Mars and Jupiter. But Eros and a few other small ones follow comet-like orbits, and occasionally give astronomers the important opportunity of making highly precise measures of motion and position. These minor planets, although merely planetary fragments, accurately obey the planetary laws of motion and reveal, after much analysis, the distances separating earth and sun, moon and earth, and the other planetary separations. As a by-product, the analysis of the measures of Eros gives us a determination of the mass of the moon.

In 1931 Eros and terrestrial astronomers had one of their occasional near approaches—a separation of only 16,000,000 miles. We knew about it long in advance. In 1928 the astronomers of the world met in Holland, and plans were made in detail for the coming "opposition." Many observations should be made of many stars in many countries. Thirty-six observatories on 5 continents and Australia took part. No one explained the plan to the diplomats, no one even mentioned to them what was going on, because governments generally recognize that the planets are not controversial subjects. A special committee examined the possibilities and made assignments. From Australia to Canada, from Argentina to Sweden, from the Japanese Royal Observatory to the Harvard station on the Modder River near Bloemfontein, Orange Free State, we did our work at the appointed times.

[1] At least that is ideally true. In practice, in a society of free enterprise, many scientific discoveries in physics and chemistry are not at all free to all men. The discoveries become trade secrets and are developed for private profit, and only eventually for "all men." As business secrets, the discoveries and developments are not open to inspection by rivals in business, or by the United Nations. Our own American system of exploiting the fruits of science points to the difficulty of international inspection—for instance, in the search of atomic plots.

The famous spectrum expert, Dr. Annie J. Cannon, of the Harvard Observatory, classified on a special series of photographs the spectra of the stars that would be used to compare with Eros as it hurried through the star fields. Where it would go we had roughly predicted, but, to improve the parallax of the sun, where it went must be known with the highest precision possible, and the colors of the stars deduced from Miss Cannon's spectrum classifications would have a bearing on the precision possible from micrometer settings. Eros is yellowish, and we would get into trouble with refraction and other difficulties if its position were derived from comparisons with deep red stars or those peculiarly blue.

After a few weeks in 1931 Eros went on about its business, becoming too faint and far away to interest astronomers further; but the thousands of measures remained. The prolonged labor of deducing the parallax lay ahead. The measures by international arrangement were sent to His Majesty's Astronomer at the Cape of Good Hope, who is now the Astronomer Royal of England, Sir Harold Spencer-Jones. To him had been assigned the heavy job of analysis.

The micrometric measures of Eros from 15 observatories entered the final determinations of the parallax. Leipzig, Greenwich, and Berlin took important observing assignments, completing the work before the British-German interchange consisted only of murderous bombs and propaganda. Finally, in 1941, at the height of the world's worst war, in which maddened, frightened nations were trying at great expense of human life and wealth to destroy each other, the Astronomer Royal calmly announced that the best value of the solar distance, thanks to the international cooperation of scientists, is 93,005,000 miles, with an uncertainty of only 8,000 miles. The new value of the solar parallax was not greatly different from the values previously determined, but the uncertainty of the determination had been reduced to a twenty-fifth of the earlier uncertainty. The new value was, of course, immediately communicated to the scientists of all the warring nations. Human knowledge of a constant of Nature had gained through cooperative internationalism. Who gained, and what did they gain, by the concurrent bitter hates of nationalism and by the slaughters of a science-engulfing war? But war could not be avoided, we say. Perhaps the eccentricity of the orbit of Eros needs international cooperation less than the eccentricities of human behavior.

The one world of stars could be illustrated indefinitely. I choose a few modern incidents that introduce the newer techniques, or show the necessity of international collaboration.

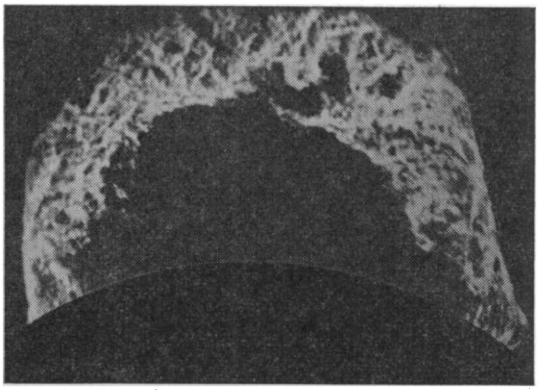
The sun is an international power plant and plays no favorites. The solar astronomers the world over began active collaboration 40 years ago. They set up central bureaus for the recording of solar phenomena. Special observatories for the study of the sun have been established in India, California, northern Chile, France, Colorado, Michigan, Switzerland, Austria, Holland, Russia, and elsewhere. Some of the observations are reported daily through a telegraphic interchange, because certain phenomena associated with the sun operate swiftly, and they influence, in a significant fashion, the ionospheric layers of the earth's atmosphere.

The sun brings together not only different countries but also the different sciences—it has shown steadily for 1,000,000,000 years and more. The problems of its radiation unite the botanist and the astronomer, the cosmologist and the physicist, the paleontologist and the weatherman. It has inspired the worship of primitive men, and its transformation of atoms of matter into the energy of radiation inspires the utmost in modern technology. The sun is indeed the guiding light to the atomic age.

But we know so little about the sun—its spots, its spicules, its prominences, and corona. To solve such mysteries, the combined efforts of all astrophysicists are needed. Let's start our exposition with the corona, that ethereal high solar atmosphere that was formerly seen only during the total eclipse of the sun. An ingenious young French astronomer, Bernard Lyot, less than 20 years ago began to solve the two-generation-old problem—how to see the elusive solar corona without the necessity of the rare solar eclipse. He installed his own eclipse-producing moon inside his telescope. He did it so carefully that the resulting coronagraph, when used on a high mountain above the earth's layer of dust—on Pic du Midi in southern France—brought out the faint glow of coronal light which is lost in the glare of sunlight unless the disc of the sun is carefully concealed by the moon or by a reasonable and effective facsimile thereof.

Following and modifying Lyot's technique, Menzel and Roberts, of the Harvard Observatory, built up and have been using for several years the only coronagraph of the Western Hemisphere. It is located high in the Rocky Mountains at Climax, Colorado, and is operated under the joint auspices of Harvard and the University of Colorado. It daily records the corona and its changing intensity, but it also records, with proper accessory apparatus, the solar prominences. Those hot solar clouds, as recorded, for example, at the McMath-Hulbert Observatory of the University of Michigan, change form from hour to hour, some explosively and some slowly. The coronagraph permits the making of continuous pictures—one exposure every half minute, for example. When these exposures are properly speeded up, we have a motion picture of the mighty gas storms on the surface of this nearby and typical star of ours.

The new photographs from the Climax station of the Harvard Observatory are selected to show various types of activity. Some are eruptive flashes, others long-continuing storms. The speeds of the motions are 3,000 to 4,000 times the speed of the winds in our own atmosphere. The photographic records are best made in the red light of the atom of hydrogen, but there are similar convulsions in the green, blue, and violet radiations of hydrogen and in the light emitted from other atoms of the solar atmosphere—for example, calcium and iron. The temperatures are



Solar prominence photographed in hydrogen light at the Climax, Colorado, station of the Harvard Observatory.

several thousands of degrees Centigrade. The pictures show that more of the motions are directed downward into the sun than upward from its surface. Why this strange tendency of more material coming down than going up? We do not fully know. The radiating material apparently is elevated to some thousands or tens of thousands of miles above the solar surface without emitting the red hydrogen light. Several mechanisms for this action have been suggested. More observations are needed, in finer detail.

It is of interest to record that the solar explosions are internationally studied—observationally and theoretically. American, French, Swedish, English, Australian, German, and now Austrian and Russian scientists are working on these problems, in part because of their basic scientific interest and in part because the radiations from the prominences and the overlying corona, and other solar radiations, operate at long distance on the earth's atmosphere, affecting the radio transmission, the Northern Lights, the magnetic needle, and possibly to some extent the earth's weather. The solar corona is still something of a mystery, especially its astonishing temperature, which may be something like 1,000,000° C, although the surface of the sun it surrounds has a temperature of only 6,000°.

The chemical composition of the material in the solar corona, for 60 years a mystery, appears, however, to be solved, and again the boundaries between nations were ignored. Following ideas and intimations provided by many spectroscopists, and especially following the work of Grotrian, German astrophysicist, Dr. B. Edlen, a young Swedish physicist, has come out with the astonishing theory that the scintillating airy corona of the sun owes its chief radiation to atoms of heavy elements. Before Grotrian and Edlen, scientists generally believed that the corona must be composed of very light elements; but now we find that the excited atoms of iron, nickel, and calcium provide most of the radiation. These atoms are highly ionized. Their outer electrons have been blown away by the excessive radiations, or whatever it is that excites and ionizes so violently these common heavy elements in the upper atmosphere of the sun.

We must learn more about this business, because what works on the sun doubtless works on the billions of stars of our Milky Way galaxy. And we shall learn more, if you keep us out of a civilization-ruining war, because the scientists of a dozen nations are turning their mathematical, observational, and interpretational skills to the question: How did that iron get into the rare upper solar atmosphere, and what is agitating it so excitedly that the excitement jets across 93,000,000 miles of space and disturbs our terrestrial radios?

The recent war, which we fought to preserve freedom and civilization, and doubtless for other reasons, did pretty badly by scientific civilization in many countries, especially interrupting the energetic and ambitious Japanese scientists. In a devastated and vanquished country, the surviving scientific laboratories and observatories are not prosperous. We record, however, one exception in Japan. Before the war there was in that country a kindly old gentleman who was recognized the whole world over as our leader in a certain phase of geodesy—in the highly organized international enterprise called "The Study of the Variation of Latitude." Dr. Hisashi Kimura was the chairman of an international commission involving geodesists of a dozen nations. To this commission had been assigned, by scientists and governments, the job of keeping track of the wandering of the poles of the earth. The true latitude of a place, of this hall for instance, is its angular distance from the equator, or 90° minus its distance from the North Pole.

It is a constant, of course, if the Pole stays put, but that is just what the North Pole does not do. For reasons that I shall not outline for you, because in part they are complicated and in part they are unknown, the Pole wanders erratically over an area about the size of this room. If you should sometime go to the North Pole and want to place a flag or carve your initials, you should make your observations of position and act quickly, or the Pole will be elsewhere.

Of course we do not need to go to the Pole to study these wanderings. We can set up an observatory almost anywhere and, with observations of a special sort, on stars in or near the zenith, check up on the unsteadiness. To do it right, however, several observatories are needed. The stations must be, for the best effect, in different longitudes and preferably all on the same latitude circle. Years ago a network of 5 observatories was set up, one each in Italy, southern Russia, and Japan, and two in the United States, one in California and one in Maryland. The observations should be continuous throughout the years. They were continued throughout the second World War, but with serious interruptions, except in Russia and Japan.

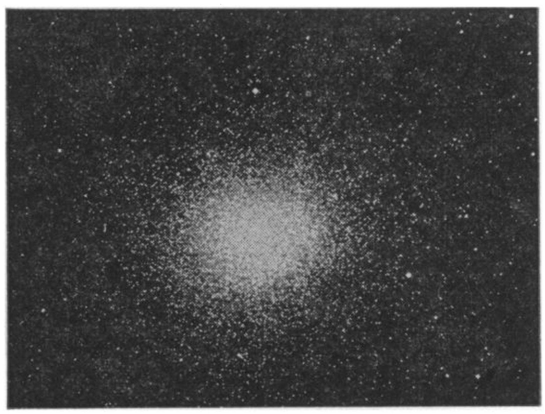
After the death of Dr. Kimura, an Italian took over the coordinating responsibilities, and the four united nations—united in geodesy, that is—now continue to trace the wanderings of the Pole, the variations of latitude, the internal and external changes in our earth that cause these irregularities and challenge the human intellect. Here again it is as though there were an international mind that wants to know about the intricacies of the physical world and, to attain its goal, hopes not to be bothered by national boundaries.

My story of the one world of stars goes all the way from the wobbles of the axis of a small planet that makes annual trips around one star to the total of all stars and the space-time in which they are involved. The relativity theory applies to the tiniest of units of energy and mass, and also to the galaxies at the outer bounds of the realm that is populated with galactic systems.

When Albert Einstein began to write his epoch-making theories, he was building directly on the mathematical explorations of Russian, German, Italian, Irish, and other mathematicians. The world-mind of mathematical physics was at work on the basic problems of the nature of the universe. National vanity, racial prestige, and stupid human strife were irrelevant.

The famous relativity theory, it was soon learned, could best be verified by astronomical tests; and at the end of the first World War, while the generals and diplomats wrangled, the British astronomers, under the guidance of Sir Arthur Eddington, went off on a hazardous eclipse expedition to test the accuracy of a German's prediction about the bending of light at the edge of the sun. The formidable equations of the relativistic cosmogonies were solved by the Russian, Friedman, the Belgian, Lemaître, and the Americans, Robertson and Tolman.

The most famous little equation in the world, $E = Mc^2$, developed out of Einstein's early work just at the time astronomers needed it to help account for the obviously long life of the sun. The paleobotanical records, coupled with geochemistry, indicated that the sun had been pouring energy into the plant leaves for 1,000,000,000, years or more. That gave us a serious puzzle—the source of so much long-enduring solar radiation—but it was resolved by nuclear physics. To energize the plants and us, the stars feed on themselves. Their matter gradually melts into radiation. Atomic energy is released in the sun at just the right rate, through the building of hydrogen into helium. Thus it has been for a few billion years, and so it will likely be for a few trillion years more.



The giant globular star cluster, Omega Centauri.

Already, years ago the atomic age was budding. For the astronomers it was in full bloom many years before the splitting sensation of Uranium 235. Experiments and interpretations in the field of atomic energy were made by the scientists of a dozen nations at the beginning of the atomic scare about 10 years ago. The one world of atoms was demonstrated as clearly as the world unity of astronomy, of biology, and of chemical reactions.

We can now build and split atoms in our laboratory, but there is nothing we can do with the galaxies, those gigantic wheel-shaped star systems, strewn by the millions throughout the recently discovered outer spaces. Nor can we do anything with those smaller sidereal systems, the beautiful globular clusters, except to study them and learn of their enormous populations of giant stars, measure their times, energies, positions, and motions, guess at their origins and destinies, and bring back to the philosophies and religions of men the raw materials useful for the reorientation of man and his works in the new world of knowledge and intellectual opportunity.

A spiral galaxy of the southern sky.

These great spiral galaxies are probably similar in form to the one in which we are located. Others are irregular, like the nearby clouds of Magellan, to which the Harvard Observatory has paid much attention for the past 50 years. Still other galaxies are spheroidal and symmetrical, looking much like super-giant globular clusters, which indeed they may be.

A month ago about 40 of us (from a dozen countries), who were particularly interested in the problems of galaxies, met in Zurich, Switzerland, to talk over the problems demanding further study. It was an international gathering. The goal was the solution of difficult problems. There was no jockeying for national prestige, no manipulating of small observatories, no struts about manifest destinies and national aspirations. It was an assembly of those representing a unified world curiosity, a unified desire to understand the universe, a united front in a special battle against our common enemy, ignorance.

In our conference we discovered that we needed additional observations to test the existing theories about the nature of space, time, and the expanding universe; and we needed more theory to interpret some of the newer surprise-observations that do not fit into the currently acceptable patterns. We want the 200-inch telescope, when ready, to tell us more about the speed of recession of galaxies heretofore too remote for spectrum analysis; and we want the new Schmidt-type reflectors to increase observationally the stability of our census of the whole metagalaxy, through searching out the millions of individual galaxics that are within reach.

From the new Baker-Schmidt telescope—the international enterprise of Eire, the United States of America, and North Ireland—we need more detailed information on the nucleus of our own galaxy. To be completed a year from now, this powerful new-type instrument will be mounted on Harvard Kopje in the Orange Free State, South Africa, and there it will be in a strategic location, with the hub of our wheel-shaped galaxy passing conveniently every day directly overhead. It should bring in answers to some of the pressing questions about the nature of our galaxy and of galaxies in general.

It is fitting that these basic researches on the nature of the physical world, for the enlightenment of all the human world, is to be accomplished with the aid of an internationally owned and operated instrument, the Eire-America-North Ireland reflector. The most valuable written document in the Harvard archives, it seems to me, is the agreement between the Dunsink Observatory of the government of Eire, the Armagh Observatory of the Archbishopric of North Ireland, and the Harvard Observatory. It is a simple statement, but its importance lies in the fact that it is jointly signed by the Catholic Bishop of Dublin and the Protestant Archbishop of Armagh, North Ireland —a document unique in history, I believe, and symbolic of the willingness and desire to cooperate across religious and political boundaries when led by the stars.

Here we have revealed, it may be, a prime function of science, and of our Association for the Advancement of Science as it enters its second century. Supranationalism and cooperation across national boundaries are so simple and effective in the sciences that we have a clear responsibility to lead the way into an era of peace and human progress without which our efforts for human knowledge and human comforts will have been in vain. Our species of man is now at one of its critical epochs. Does it survive the crisis, through the use of intelligence and the submersion of avarice, or does it join the fossil biological failures of the past, which, through inability to meet their crises, have long ceased to greet nightly the world of enduring stars?