SPECIAL ISSUE:

INTERNATIONAL SPACE SCIENCE

The prospects for international cooperation are hopeful, and with the restoration of the US program a new golden age may be in store.

Thomas M. Donahue

The articles in this special issue of PHYSICS TODAY, together with Minoru Oda's article on the space science program in Japan (December, page 26), portray a research field beset by contradictions. The space research programs of the USSR, Europe and Japan are flourishing. Their scientists are busy analyzing the results of recent successes in Solar System exploration and in astrophysics. They are also busy constructing new projects, some of which are joint international ventures involving a substantial pooling of resources. International cooperation is the *mot d'ordre* in Europe and the USSR, where enthusiasm and optimism are pervasive.

In contrast, American space research would be effectively grounded if it were not for the several productive orbiting relics of its once prominent space research program. Stricken by the inability to launch spacecraft built during the past five years (and sometimes even before that) and inhibited by national policy from participating fully in the large-scale cooperative ventures that are so much the present mode—particularly ones in which the USSR is the principal participant—the US is keeping a rich collection of scientific spacecraft in storage. At the same time, the US continues to build more spacecraft, most of them complex and sophisticated, and to develop elaborate plans that project the future of space research for the next 30 years or more.

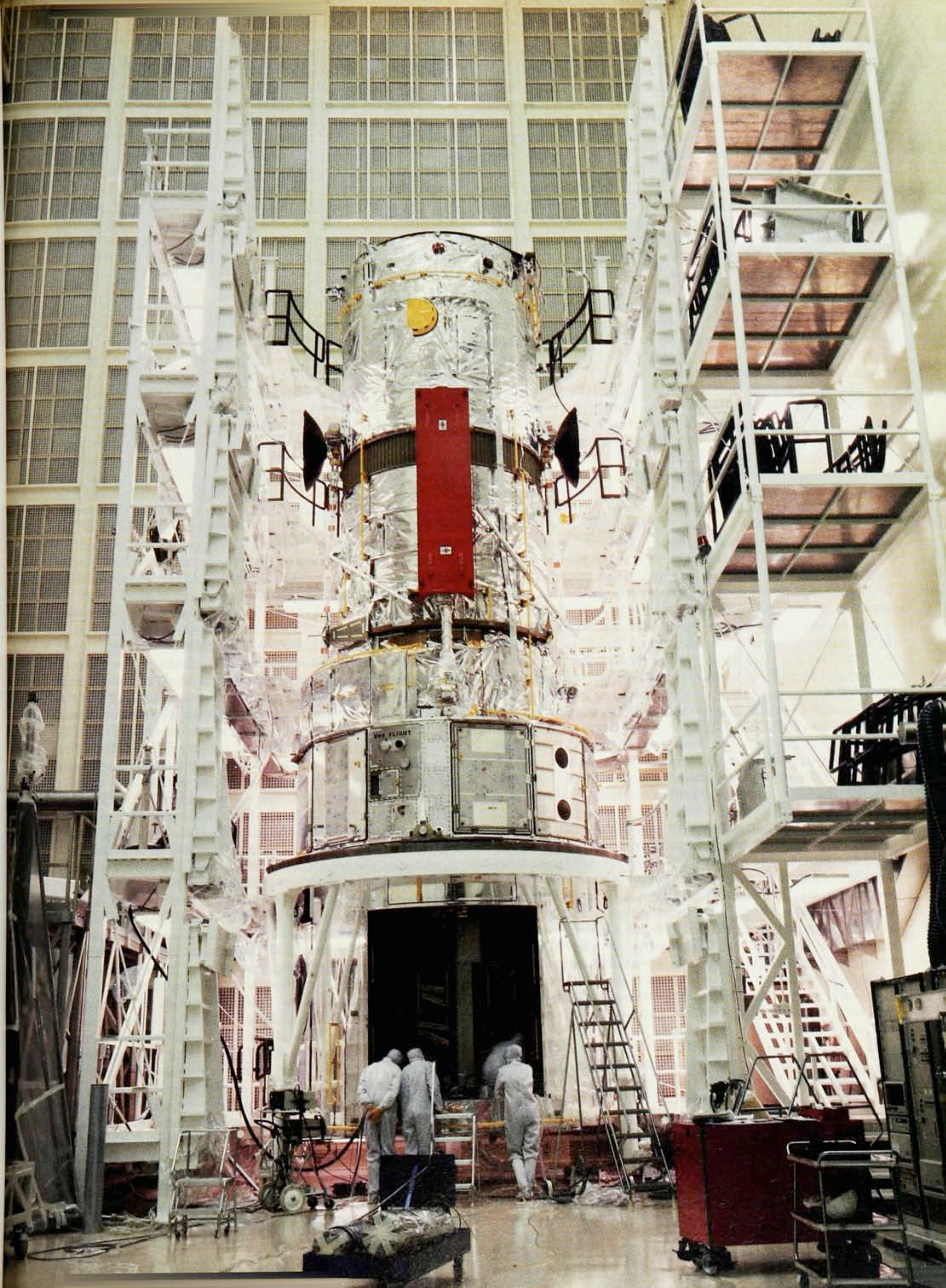
The articles by Roald Z. Sagdeev (page 30) and W. Ian Axford (page 42) describe the present activities and plans for space research in the USSR (as well as in the Eastern states involved in Interkosmos) and in Western Europe. Interkosmos, the agency of the Soviet Academy responsible for coordinating international activities in space science with other space agencies worldwide, has plans for Martian exploration, and it is inviting the rest of the world to participate. The balance of the Soviet space science program is not meager either; the Soviets have recorded solid accomplishments in astrophysics and space plasma physics, and they promise more in the next few years. Europe looks forward to its carefully constructed series of missions called Horizon 2000, which would build on successes such as the Giotto mission to Comet Halley. Both Soviet and European programs are supported by simple, effective and reliable launch systems—a necessary condition for a successful space research program.

Japan also goes ahead, mostly on its own, with a modest but effective and methodical series of missions. The Japanese program has focused primarily on x-ray astronomy, solar-terrestrial physics, communications and meteorological satellites, and it has begun a strong developmental effort in microgravity experiments. A new booster system called the H-II should make Japan a major competitor for international commercial launches. But even the Japanese are into the cooperation business. The UK has a role in the current Japanese x-ray satellite project, Ginga. Japan and the US plan to collaborate in the Geotail component of ISTP, the International Solar Terrestrial Physics Program. Negotiations are still under way between Japan and the US for a Japanese laboratory module that would be an important element in the US space station.

US renewal

Once the US resumes satellite launchings, it will deploy more spacecraft, of higher quality, between 1989 and 1992 than it launched during the golden years of the 1960s and 1970s. Joseph Alexander and Frank McDonald document this unprecedented potential in detail (see page 56). In astrophysics five important missions are either ready or being prepared for launch. These missions include two of the five "great observatories" foreseen in the report of the National Research Council's Astronomy Survey Committee:[1] the Hubble Space Telescope and the Gamma Ray Observatory. In addition NASA has now asked Congress to allow it to begin constructing the Advanced X-Ray Astrophysics Facility for deployment in 1991. The Planetary Exploration Division of NASA has three missions, including the long-suffering Galileo mission to Jupiter, that are planned for launch between now and 1992. Moreover, the division will soon be asking for two more

Hubble Space Telescope is maintained in storage in the high bay, a giant clean room at the Lockheed Missiles and Space Company in Sunnyvale, California, as it awaits the renewal of US launch systems after the Challenger disaster of January 1986. Now scheduled for launch on 1 June 1989, the Space Telescope will be one of the first scientific payloads to be put in orbit by the refurbished space shuttle. The instrument symbolizes both the frustrations of the US space research program and the promise of a rich yield of space science for all participating nations in the 1990s.



missions, a comet-asteroid project and a mission to Saturn and Saturn's moon Titan.

Scientists investigating solar and space plasma physics have six spacecraft ready or in preparation for launch between now and 1992, including the US components of ISTP. Earth scientists are constructing three complex satellites, including the elaborate Upper Atmosphere Research Satellite and the French–US Ocean Topography Experiment (TOPEX–Poseidon). The Earth Observing System is in the wings. At least four space shuttle flights are planned for microgravity studies in life and material sciences before 1992. Not counted here are the newly authorized or requested moderate-sized Explorer missions so important to the university community. These are the missions fulfilling Freeman Dyson's dictum that "quick is beautiful." Finally the Stanford gyroscope experiment, which many consider the most challenging technological tour de force ever planned for a space experiment—has been designed to detect the relativistic effect of frame dragging by the rotating Earth.

The purpose of this recital is to put into proper perspective the jeremiads that issue these days from the US space science community, the Space Science Board included. While it is true that a crisis in space science has persisted for almost a decade, that crisis has nothing to do with the number or the sophistication of the scientific projects started by NASA. To say that the space science program of the US will be restored to parity with the rest of the world when the spacecraft I have listed have been successfully launched would be an understatement. In fact, the strength of space science research worldwide will be without previous parallel during the ten years after the US begins to launch scientific spacecraft again. For while the US program has been on hold, the rest of the world has also achieved excellence in space science. Thus one can anticipate a time of incomparable richness in the space sciences, which, ironically, will be due partly to the collapse of the US launch system that took place in the late 1970s.

It is in this context that one should read the article by Louis J. Lanzerotti and Jeffrey D. Rosendhal (see page 78). The policy measures they recommend for the health of space science pertain to the space program of the future and have only limited applicability to the present (decade long) crisis. That crisis will end when the US achieves a reliable launch system.

I do have one serious concern about the future health of the US space program that Lanzerotti and Rosendhal do not analyze. It is no longer clear that the administrative structure at the space agency is adequate to manage large programs with the skill and effectiveness it once mustered. The past decade and a half have taken a dreadful toll at NASA headquarters as well as in the NASA research and spaceflight field centers. The civil service staff has dwindled, and contractor personnel now do most of the work formerly done by NASA employees. The concern that I (and many of my colleagues) have is that the present civil service staff may not be large enough or experienced enough to manage the contractors and control the giant aerospace companies that build the NASA spacecraft. At risk are the quality of the hardware and the cost of the projects now being developed. The next real crisis in the space program may involve the reliability and price of the spacecraft being prepared or planned for the missions of the 1990s.

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As for the more distant future, several years ago NASA asked the Space Science Board to look ahead to the first two decades of the 21st century. The goal was to predict which scientific questions would then be addressed by the disciplines of space science. The board accepted the assignment and completed a large-scale two-year study almost two years ago. Since that time the study has been reviewed and polished; its unveiling has been awaiting an auspicious occasion. That occasion will be on 27 June, when, to mark the 30th anniversary of the first meeting of the Space Science Board, the report[2] will be released and a pair of symposiums will be held at the National Academy of Sciences in order to review the triumphs of the past and the expectations for the future of space research.

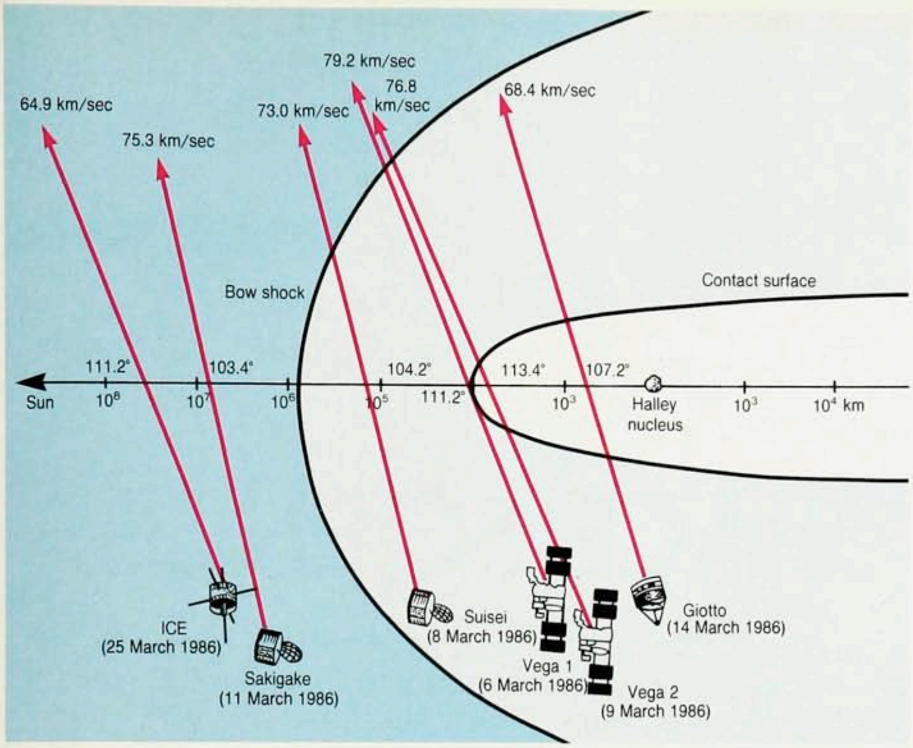
Toward the 21st century

Our study foresees the need for many large-scale undertakings in various space science disciplines during the early decades of the next century. According to the study, in order to be able to address the questions likely to be raised at that time, investigators will need to construct and deploy large and technologically challenging observing structures in space. Numerous projects, some ambitious in scope, would be required to implement the study recommendations. No elaborate costing exercise—only a comparison with the cost of the space science projects now being undertaken—is needed to demonstrate that a substantial increase in the world's budget for space science will be necessary if the recommended projects are to be completed during the nominal 20-year period covered by the study. Nevertheless, the participants in the study (who numbered more than 200 people) would not conclude that their recommendations should be disregarded. The scientific issues are fundamental, and they cannot be addressed without space vehicles. The work needs to be done.

What one can conclude is that either the time allotted for this work must be longer than 20 years or the costs of building devices for space science and of launching spacecraft must be drastically reduced. It is widely accepted that the aspirations of those who would move large human enterprises into space are incompatible with the present cost per unit mass of getting them there. The challenge implicit in reports such as the ones by the Space Science Board, by Sally K. Ride for NASA[3] or by the National Commission on Space,[4] all of which call for the eventual human habitation of the Moon or Mars, is to make those undertakings affordable. The first step is to get the cost of hardware and of launch systems dramatically down.

Are people needed on site (in space) in order to carry out the various space science projects? The participants in the study by the Space Science Board debated this perennial issue, and they concluded that for the so-called microgravity sciences—particularly space medicine and the early phases of material and fluid studies—the answer was yes. For the rest the answer was either no or not proved. There was a consensus—not unusual in such discussions among space scientists—that the manned space program would continue for reasons other than its utility to science. There was even a consensus among members of the study steering group that they would not be comfortable if the US were to abandon its manned space program.

Nevertheless, the participants recommended against sending people on forays or expeditions to carry out scientific missions in remote places. Instead, they proposed, people should be employed to do science in space only where an inhabited zone has been secured, perhaps along the lines already established for scientific work in Antarctica. Such an inhabited zone would provide a setting in which scientists could work comfortably and



Rendezvous with Comet Halley in March 1986 were made by satellites of many nations, as depicted in the figure. For each flyby the figure indicates the incident angle between the satellite's path and the comet's orbit, as well as the distance between the satellite and the comet on the date of nearest approach. Internationalism was fostered on several of these missions by the multinational experimental payloads aboard and by subsequent sharing of the data obtained during the flybys. Moreover, all the flights were coordinated by the efforts of an interagency group made up of NASA, the European Space Agency, the Japanese Institute of Space and Astronautical Science and Interkosmos for the USSR and the Eastern bloc.

effectively. Eventually, the participants concluded, that zone might be extended to and beyond the Earth's orbit—to the Moon or to Mars, for example—but scientific studies outside the zone should be carried out systematically by automated stations or spacecraft and not by astronauts.

The four articles that follow and the earlier one by Oda deal with the various space programs separately. As I have indicated, however, a common thread among them is international cooperation, and it is very much on the minds of space scientists today. During the earlier period of US dominance, NASA offered Western European and Japanese scientists the chance to participate on US science missions, even as hardware principal investigators. The US also joined other national partners in building spacecraft and in sharing the data obtained during flight. The USSR entered the game of cooperation somewhat later than the US and rather more tentatively, although its joint undertakings with the French began early in the 1960s and have been quite productive.

In the past few years all this has changed. While flight opportunities in the US have decreased and then vanished, the USSR has increased the rate at which it has launched major missions. Furthermore it has conspicuously increased the opportunities it offers to scientists in the West as well as in the East to participate in its flight programs. It has brought its operations and planning procedures out of the shadows and thereby acquired a well-deserved reputation for *glasnost* and international cooperation.

By contrast, the US has hung back. Embarrassed by its inability to reciprocate and deterred by its fears of technology transfer and its general reluctance to traffic with the "Evil Empire," it has withstood the blandishments of its charismatic Soviet rival. Fortunately this attitude, which has prevented US scientists from taking part in scientific activities readily accessible to colleagues in other countries, seems to be changing. The bilateral agreements between the US and USSR, which were allowed to lapse after the start of the war in Afghanistan, have been re-established, and new discussions are under way. As I write this article, scientists are awaiting the next summit meeting with hopes that it will produce an agreement sanctioning and promoting cooperation between the US and the USSR at a practical level. It is certainly time for such an agreement.

These measures will obviously bring benefits to science, if the cooperative programs are carefully constructed. There will also be political benefits to the US, which must recognize that the rules of the game have changed. The competitive mode of the past, in which the US could offer opportunities to its friends and ignore its rival, is no longer a useful option. The US will have to be seen as willing to work with all of its international counterparts, including the USSR, or else watch its prestige diminish. The competition today is to be the nation that appears most cooperative. An important corollary is that NASA, as it regains its forces, must be willing to exchange its old way of doing business—as a host (sometimes gracious but always autocratic) to the space scientists of "friendly" countries—for a relationship of partnership with scientific peers.

As US space scientists await the resumption of shuttle flights and the delivery of a new series of unmanned launch vehicles, they face an exhilarating time. Let us hope it is also a second golden age.

References

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