Background and current ISRO initiatives in microgravity research programme

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Introduction

THE main goal of the Indian Space Research Organization (ISRO) is to harness space science and technology for applications in the areas of communications, meteorology and remote sensing of earth's resources. However, with marginal additions to the resources, ISRO has been in a position to implement a number of space science-related projects and programmes, particularly in the areas of space meteorology, geosphere–biosphere interactive phenomena, aeronomy and space astronomy. Future activities would include other space science and applications areas such as planetary exploration, microgravity science, etc.

Early efforts

Since the organization of the very successful international workshop on 'Materials and Materials Processing in Space', jointly sponsored by ISRO and the Indian Institute of Science (IISc), held during 24–29 September 1979 at Bangalore under the chairmanship of S. Ramaseshan, not much could be done to pursue the formulation of a possible Indian programme in the field. During the workshop, an overview of the fundamental aspects of behaviour of structural properties of materials under microgravity environment was presented by Ramaseshan, followed by papers related to the phenomena of convection, adhesion, solidification, crystal growth, capillary motion, etc. and their implications under microgravity condition. Indian Academy of Sciences, Bangalore has published the proceedings of this workshop; orders can still be placed for obtaining copies of this book @ Rs 100. One of the recommendations of the workshop was to develop a suitable drop tube facility in India for conducting experiments with relatively short turn-around time. The matter was further pursued by ISRO's Advisory Committee for Space Science (ADCOS) and a detailed proposal was prepared by the group led by K. Chattopadhyay, IISc, Bangalore. However, due to various reasons related to priority of programmes, this facility could not be supported.

The first opportunity to gain some experience in the design and development of microgravity experiments related to materials processing in space was provided to Indian scientists through the joint Indo-Soviet cosmonaut flight on-board *Salyut-7* space station in 1984. The scientists from the Defence Metallurgical Research Laboratory (DMRL) led by P. Ramachandrarao developed an experiment to study the effect of undercooling of Ag–Ge alloy microstructure under space environment (for details please see the article by Ramachandrarao in this special section).

Current ISRO initiatives

In view of recent achievements in satellite and launch vehicle technologies and also successful projects in developing and operating a number of ground-based, balloon, rocket and satellite experiments for scientific investigations, ISRO has initiated activities to revive interest in the field of microgravity research. As a first step and under the aegis of ADCOS, a number of scientific meetings, brain storming sessions and workshops have been organized.

In response to interest shown by university scientists, a discussion session was organized at the ISRO Satellite Centre (ISAC), Bangalore with the scientists from Anna University, Chennai on identification of possible projects with ISRO collaboration. Preliminary proposals discussed at the meeting related to GaAs crystal growth, DNA/protein crystal growth, electrophoresis, cell culture, etc. During this meeting it was suggested that these proposals and those from other groups could be discussed at a national level for evolving a microgravity research programme.

One-day national workshop

As a result of suggestions from scientists, a one-day national workshop on 'Materials Processing in Space and Space Biotechnology' was organized by ISRO at Bangalore on 1 August 1997. The main objectives of the workshop were (a) to create awareness amongst the scientific community working in various research institutions and universities about the microgravity research potentials and ISRO's interest to promote this activity in the country by providing necessary technology and mission support; and (b) to identify a few PIs who would prepare research

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proposals and implement the development of possible microgravity experiments for placing on space-based systems.

About 60 scientists from 15 research and academic institutions and universities were invited to participate in the workshop and about 35 of them attended. The workshop was inaugurated by K. Kasturirangan, Chairman, ISRO who mentioned that even though a large number of experiments have been carried out in space microgravity environment by NASA, ESA and others, a number of phenomena such as combustion in space, crystallization of molecular organizations, melting and solidification of metals and alloys, dynamics of crystal growth, etc. are not fully understood. He also informed that during the IX plan period ISRO might consider supporting innovative proposals on microgravity science research.

The workshop was organized into three technical sessions: (i) Material Science and Fluid Physics chaired by S. Ramaseshan, (ii) Space Biology and Biotechnology chaired by Kunthala Jayaraman and (iii) Microgravity Research Platforms chaired by K. Chattopadhyay. The technical presentations were followed by a panel discussion chaired by K. Kasturirangan and S. Ramaseshan, with H. Sharat Chandra, K. Jayaraman, M. A. Viswamitra, N. Rudraiah and V. Nanjundiah as panellists. The panel recommended the following course of actions: (a) Working Groups (WGs) could be constituted by ADCOS to generate innovative and novel ideas for conducting microgravity experiments; (b) The WGs should meet periodically, so as to come out with necessary recommendations on a microgravity programme; and (c) Explore the possible collaborative arrangements with China, Russia, Europe and USA for planning Indian microgravity experiments on-board space platforms, development of recovery modules, etc. in a time period of 4 to 5 years. A number of other recommendations were made during the deliberations of the workshop. These include the following:

- Since there is adequate interest and expertise in the Indian scientific community to undertake a multi-institutional Indian programme, ISRO may consider sponsoring and supporting such an activity.
- Capabilities exist in a number of research centres/ laboratories to carry-out 1 g experiment, computer simulation studies, payload development, etc. Also ISRO and research laboratories have the capability to develop payload recovery systems and specific space missions. These strengths could be pooled to generate a viable programme.
- Creation of a database on Indian activities in the field with links to global databases.
- Utilization of any opportunities on International Space Station (ISS) which would provide long duration microgravity experiment facility.
- Utilization of data available from foreign missions through international collaboration.

Standing working groups on microgravity research

As a follow-up of the above recommendations, three Standing Working Groups (SWGs) have been constituted by ADCOS.

SWG-1: Materials processing in space (Chairman: S. Ramaseshan);
SWG-2: Fluid physics and dynamics (Chairman: R. Narasimha);
SWG-3: Space biology and biotechnology (Chairman: H. Sharat Chandra).

A number of meetings of these SWGs have taken place. A few proposals of preliminary nature are also discussed and some of these are recommended for further consideration. In order to generate novel proposals from a larger cross-section of scientists, it has been suggested that insertion of an 'Announcement of Opportunity' inviting proposals for conducting microgravity experiments would be very helpful. Such an advertisement appears in this issue of *Current Science* along with this special section comprising a collection of review articles for detailed technical information on Indian effort in this direction. Another recommendation made by the SWGs is that initially a few experiments could be carried out by the Indian scientists by designing suitable payloads for a possible balloon-drop payload system. The national balloon facility at Hyderabad can launch balloon-carrying payloads ~ 1 ton to a ceiling altitude of about 40 km. 'Free fall' of the balloon/payload from this altitude is estimated to provide ~ 10^{-3} g condition for a period of about 60 s. Initially small piggy-back experiments on-board on-going balloon flights could be tried out. For future studies, a special balloon module/capsule would need to be designed for providing on-board facilities such as power, video imaging, efficient recovery system, telemetry interface, etc. For the piggy-back experiment the existing facility of balloon gondola mainframe, telemetry, recovery channels, etc. could be used by the experimenter. The capsule would be designed to provide a better microgravity environment and also integrate a number of individual experiments for combined performance and recovery. Few proof-of-concept trial experiments are being planned by scientists, utilizing the present balloon-drop facility at Hyderabad to study aspects of multi-phase fluid dynamics-related problems.

Conclusion

Recently some initiatives have been taken by ISRO to revive and energize the activities of research related to the area of microgravity science. Following the one-day national workshop organized to identify worthwhile scientific problems to be pursued, three SWGs have been constituted for further discussion by the scientists from research institutions and universities and technologists

from ISRO. These SWGs have completed their first round of discussions and have made a number of recommendations. These include further effort in soliciting research proposals, detailed assessment and specifications of technology requirements and to conduct balloon-drop experiments using the available facilities with suitable augmentation and development of a recovery microgravity capsule, establishment of an Indian database and participation in foreign missions with collaborative projects. The future of such investigations in India would possibly include, apart from the balloon-drop capsule development, rocket and satellite payload recovery system development and participation in the ISS for microgravity research.