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Cover illustration

Distribution of the disturbance over the solar surface for the six modes of solar oscillation characterized by spherical harmonics with degree l and azimuthal order m (clockwise from upper left): (l, m) = (2,0), (2,2), (5,5), (20, 20), (20, 17), (20, 0). Red and blue regions correspond to positive and negative disturbances at the phase illustrated. The pole is at the top; for clarity, it is inclined by 30° towards the viewer. *See: J. Christensen-Dalsgaard, p. 71.*

Maurice Jacob, advisor to CERN's Director-General, who chairs the ESA Survey Committee's fundamental physics in space panel argues that to be effective, physicists working in the field need a tangible framework for organizing activities.

A Focus is Essential

Some 100 proposals for mission concepts for 2005 and beyond were received by the European Space Agency in the framework of its Horizon 2000-Plus programme. Most were new proposals as only a few were carried over, often in a modified form, from a call made in connection with the next Medium-sized mission. Fundamental physics in space (cosmology, general relativity and gravitation, new forces, and astroparticle physics) attracted 31 proposals because many scientists were clearly intrigued by the possibilities.

A Topical Team for fundamental physics, one of five set up in January (the others are for research on the solar system and deep-space astronomy), presented its conclusions to ESA's Survey Committee on 11 April following the symposium *Future Fundamental Physics Missions in Space and Enabling Technologies* (El Escorial, 5-7 April). None of the proposals, as presented, were recommended. Instead, the overall concept, purpose and means which each proposal considered were reviewed, for much work is needed before all the enabling technologies will be available, and progress may allow more to be done than is presently expected.

A large Cornerstone mission early next century aimed at detecting gravitational waves using a long-baseline laser interferometry along the lines of the Laser Interferometry Space Antenna (LISA) proposal was recommended. Other, less ambitious, projects were strongly endorsed, notably: tests of the equivalence principle; tests of gravitation theory; detection of magnetogravitational effects such as those associated with the Earth's rotation; exploration of the relation between mass and the curvature of space. As the flagship of fundamental physics, the detector mission should be loaded with promise and unchallenged interest. But other, strong contenders will originate from the other Teams, and astronomy certainly has a legitimate priority. A Cornerstone in fundamental physics is thus only realistic if at least three Cornerstones are envisaged.

The detection of gravitational waves on the ground at reduced cost will be tried with efficient means before any space mission (the large VIRGO interferometer is being constructed near Pisa, along with two similar LIGO interferometers in the USA). Detection in space is strongly supported, nevertheless, since it is complementary (owing to noise, detection on the ground is blind to frequencies below 1 Hz whereas detection in space can extend to frequencies of the order of 10^{-4} Hz). Cataclysmic events (*e.g.*, supernova collapse) are observed at high frequencies, but one needs several detectors for localization. At low frequencies, on the other hand, one can observe for a long time phenomena such as the formation of massive black holes: rotation of the detector as it orbits the Sun provides localization. The stimulus for such observations comes from the fact that the absence, for example, of gravitational radiation streaming from many existing binaries would undermine gravitation theory. Moreover, a window for observing black holes would be opened up if gravitational radiation is detected, and a deviation from the universality of free fall would allow new postulated types of interactions to be studied. On the more speculative side, if there is a strong gravitational noise background originating from the Big Bang it should extend over the whole frequency range. Technically, the realization of high-performance clocks, laser interferometers, and control systems for adjusting the micro-acceleration of drag-free systems offer many challenges at the boundary between physics and technology.

We can thus anticipate a bright future for fundamental physics in space, with a strong community of physicists devoting its full attention to the field. However, the effort required to move from concepts to missions needs a large constituency manifesting itself through a life of its own. Activities should be more continuous than the sporadic events associated with calls for concepts as there is much to discuss, assess and debate before missions are flown.

The relevant physics communities already have a sizeable overlap, as demonstrated by the EPS *Large Facilities in Physics* conference (Lausanne, 12-14 September 1994) where ground- and space-based detectors will be considered side-by-side. An Interdivisional Group or a Section of the joint EPS-European Astronomical Society Astrophysics Division could provide a framework for the constituency to manifest itself, otherwise a new structure may have to emerge. The development would come at a time when many countries are bringing together support for facilities in fundamental science ranging from particle physics to astronomy. Natural channels are emerging for funding "in-between" fields such as fundamental physics in space, so requests for support from a specialized community can be listened to. EPS can help the community receive the attention it deserves by confirming that a strong and thriving constituency is represented.