Foreword

Throughout 2009, we will have been commemorating the four hundredth anniversary of the first observations made by Galileo, this being marked by international celebrations, as part of the International Year of Astronomy, organized at the initiative of the United Nations, and steered, worldwide, by the International Astronomical Union (IAU) and UNESCO. As the outgoing President of IAU, I am wont to say that this year 2009 is also a celebration of the golden age of astrophysics. Indeed, the spectacular advances achieved by technology, over the past 30 years or so, and the outstanding uses our astrophysicists have been able to put them to, have brought about an utter transformation of our vision, and understanding of the Universe, and its components – from the internal behavior of the Sun to star formation, from the evolution of galaxies, now delineated virtually throughout the 14 billion years the Universe has existed, to the evolution of large-scale structures, these vast cosmic webs traversing space. Fundamental physics is likewise undergoing an upheaval, particularly as regards particle physics, as it seeks to identify the engine driving the acceleration in the expansion of the Universe, and the baffling mass carriers that make up dark matter, the largely dominant component of matter, across the Universe.

In the midst of this upwelling of knowledge, CEA can draw on its own outstanding assets, ranking as a significant player, gaining worldwide recognition, and indeed increasingly so. Thus, three research scientists at CEA, involved in such topics, have already been awarded European Research Council (ERC) grants. Initially, CEA elected to embark on a space science, and technology effort as France, and Europe made the decision to go in for space science. Consideration was immediately given to the detection of high-energy cosmic radiation (X-ray and gamma photons, particles), which are unable to penetrate the Earth's atmosphere – and thus to CEA, which, owing to its chief remit, was recognized for its expertise as regards the detection of such radiation. From the outset, CEA had been one of the main laboratories, in Europe, engaged in mounting high-energy radiation detectors on balloons, rockets, and, subsequently, satellites.

Working alongside the researchers, and engineers developing the instruments came astrophysicists, their arrival strengthening the link between experimental know-how, and the interpretation of the findings obtained, advancing our knowledge of the Universe. Over the years, this fruitful collaboration resulted in markedly boosting CEA's ability to suggest the instruments, and missions best suited for the purposes of resolving the most pressing issues, this allowing CEA to be selected by the relevant French, and international organizations, to provide numerous instruments, both spaceborne, and ground-based. The outstanding success may be noted, for instance, of the SIGMA gamma-ray camera, carried on a Russian satellite, which allowed the discovery of microquasars, i.e. stellar-mass black holes giving rise to phenomena similar to those arising in quasars.

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The interest being shown for new scientific issues, e.g. the gas content of galaxies, and the investigation of star formation, together with the opportunity this afforded, of taking advantage of the synergies arising with teams at CEA's Technological Research Division (DRT), led the astrophysicists at CEA to further become involved in infrared astronomy, in the early 1980s. The European Space Agency (ESA) was readying the first infrared space observatory, ISO, and there was an opportunity for CEA to take on main project leadership for a crucial instrument, the camera. This entailed securing the availability of arrays of infrared detectors, which, at that time, could not be imported from the United States. These detectors called for a specific development effort, if they were to operate at low noise levels, and the Infrared Laboratory, at CEA/LETI, took on this venture, quite successfully. The findings obtained by ISOCAM, as regards star formation, and the evolution of galaxies, showing that starbursts, and infrared-bright galaxies had been far more frequent in past epochs, brought about a revolution in this area. Nowadays, very large numbers of astrophysicists, around the world, are investigating the various stages in galaxy evolution; ISOCAM findings have been corroborated, and considerably expanded, by the US Spitzer satellite, and major advances are presently anticipated, with the Herschel satellite, which has just been launched. For Herschel, DRT developed innovative detector arrays, also used for ground-based purposes, on the APEX radiotelescope, while CEA's Physical Sciences Division (DSM) was very actively involved in the construction of two of the three instruments carried by the satellite.

Ground-based astronomy has likewise made major strides, and the development of instruments, for such purposes, now calls for quasi-industrial methods. The know-how gained by CEA, with regard to space technologies, has enabled the organization to deploy a major instrument, VISIR, on one of the giant unit telescopes at VLT, providing unique information regarding protostellar disks, within which planets are formed. Research scientists at the Institute for Research on the Fundamental Laws of the Universe (IRFU) are also heavily involved in cosmology, carrying out observational investigations from the ground, with the MEGACAM camera they have constructed for the CFHT telescope, and from space, with XMM–Newton, pending the wealth of data on the cosmic microwave background being anticipated from the Planck satellite.

Currently, CEA has also gained strong expertise in the area of numerical simulation. This enables major advances to be made on topics that are also subject to ground-based, and spaceborne investigations by CEA researchers. Thus, subsequent to the success of the GOLF experiment, which measured the oscillations of the Sun, a detailed modeling effort is currently ongoing, of the interior of our star. The acceleration of cosmic rays is likewise being simulated, synergetically with observations from satellites to which CEA has made a contribution in terms of instrumentation (XMM–Newton, INTEGRAL), and from others, for which CEA is associated to the science involved, e.g. the recently launched Fermi satellite, or, on the ground, HESS, which is detecting high-energy gamma rays to a high locating precision. The most spectacular results concern simulations of the evolution of the large-scale structures of the Universe. These highlight the importance of the infall of cold gas flows in those regions where mass is coming together, making it possible to ensure better preparation for forthcoming missions, to measure the properties of dark matter, and of dark energy, missions in which CEA is acting as a driving force.

The near future is highly promising, with the ongoing stream of findings from XMM–Newton – which, among other results, is providing CEA with extraordinary findings regarding galaxy clusters – as from INTEGRAL, Fermi, and ground-based instruments, together with the initial operation of Herschel, and Planck; concurrently, at CERN, LHC could be achieving a breakthrough, as regards the puzzle of the nature of dark matter. At the same time, CEA is playing a major part in the design of an infrared imaging camera and spectrometer, intended for JWST, the ambitious successor to Hubble; likewise for a new instrument for gamma-ray astronomy, being constructed in collaboration with China; and it is the prime mover, in Europe, of a new cosmology mission.

As regards the more distant future, many possibilities are shaping up, in the realm of space science, while the quest for high-energy neutrinos, from the bottom of the seas, is about to begin. CEA's grand cosmic adventure is set to continue.

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