1960 and Thereabout: The New Astronomy
(notes for a history still to be written)

Giancarlo Setti
Department of Astronomy
University of Bologna

1. Preamble

In the two decades straddling the year 1960 our vision of the universe was dramatically changed by the application of new observational tools. New branches of astronomical research rapidly developed involving both ground and space based technologies: the domain of the optical telescope that had lasted for several centuries since the time of Galileo was finally broken and unexpected riches of celestial phenomena were revealed.

Radio astronomy was the first of the new astronomical disciplines to widen the horizon of astronomical research. As a matter of fact the very beginning of radio astronomy goes further back to the years 1932-35 when Karl Jansky[(1)] discovered the galactic emission at decametric wavelengths, followed by the work of Grote Reber[(2)] that identified the galactic spiral arm emission at 160 MHz and detected a weak radio signal from the Sun. But it was only after World War II that this field of research got real momentum with the application of improved technologies and much engineering expertise developed for the radar systems during the war. The list of discoveries, not to mention the studies of the active Sun, is impressive:

1949 – The radio sources Virgo A and Centaurus A are identified with the galaxies M 87 and NGC 5128, respectively.
1951 – Muller & Oort[(3)] and Ewen & Purcell[(4)] detect the 21cm line of the interstellar neutral hydrogen predicted by H.C. van de Hulst (1944) leading, among others things, to unprecedented studies on the structure and dynamics of galaxies including our own.
1954 – Cygnus A, the third strongest extragalactic radio source, is identified[(5)] with a relatively faint galaxy at a distance of about 260 Mpc, the corresponding emitted radio power being ~ 10^{45} erg s^{-1}, that is about a trillion times the power of the Sun; radio astronomy provides a new powerful tool for the study of the evolution of the universe, although the origin of this large release of energy is obscure (among the hypothesis colliding galaxies of matter and antimatter).
1963 – Discovery of the quasars 3C 273 and 3C 48, as a result of the accurate radio positions obtained by Cyril Hazard and collaborators[(6)] and the intuition of Marteen Schmidt in the interpretation of the optical spectra[(7)], a new class of objects of great importance for astrophysical cosmology: extremely powerful at both radio and optical wavelengths indicate the galactic nuclei as the site of impressive explosive events.
1963 – Detection of the OH molecule at 18cm wavelength in the interstellar gas, marking the beginning of a painstaking analysis of the composition and distribution of molecules and molecular clouds in the interstellar gas with far reaching conclusions about the formation of stars.
1965 – Discovery of the cosmic microwave background by Nobelists Penzias & Wilson[(8)], which represents the pillar of the hot big-bang model.
1968 – Discovery [(9)] of the pulsars confirming the existence of the neutron stars, with far reaching consequences on many subjects (late phases of stellar evolution, physics of dense matter, particle accélération, etc.)

Thus radio astronomy has played a profound role on our changing view of the universe and of its constituents and has greatly influenced the development of astronomical research. By the early 1960s the first great catalogues of radio sources became available and counts of radio sources

provided the first solid evidence of an evolving universe, while the discovery of new classes of objects, alongside with theoretical investigations on the nature of their radio emission, clearly indicated the need of a fresh look at the physics of the energy mechanisms at work.

During the same time period the development of space research has permitted an exploration of the cosmos at photon wavelengths that are otherwise completely blocked by the terrestrial atmosphere leading, in particular, to the birth of X- and γ-ray astronomy.

By the late 1940s the X-ray emission from the Sun was revealed by means of detectors on board V-2 rockets, but it is only in 1962 that the first extra-solar cosmic X-ray source, *Scorpius X-1*, was discovered together with the cosmic X-ray background by Giacconi, Gursky, Paolini and Rossi[(10)]. By the end of the 1960s the detectors on board high-altitude rockets lead to the discovery of X-radiation from several diverse celestial bodies: diffuse and point-like emission from the Crab Nebula, the first extragalactic source identified with the galaxy M87, the relatively close radio galaxy Centaurus A (NGC 5128), the tentative detections of the Seyfert galaxy NGC 4151 and the quasar 3C 273 (later confirmed by the UHURU satellite). The field was mature for a systematic survey of the X-ray sky, essentially accomplished in the following decades with a number of dedicated X-ray satellites. Thus X-ray astronomy has developed as a major discipline, on the same footing as optical and radio astronomy, to discover and investigate the very hot and energetic plasma in celestial objects and contributing to a much deeper understanding in almost all fields of astrophysics: notably, the physics of the active Sun and stellar coronas, stellar evolution and binary systems, supernova remnants, collapsed objects and discovery of black hole candidates, the physics and evolution of active galactic nuclei (AGN), origin and distribution of the hot intergalactic gas in galaxy clusters, the evolution of galaxies and matter distribution in the universe.

Another asset for high-energy astrophysics in the 1960s was the discovery of energetic γ-ray photons (> 100 MeV) from the plane of the Galaxy with the OSO-3 satellite[(11)]. Later it was found that this emission is partly contributed from point-like sources, not resolved due to the limited angular resolution of the telescope on board OSO-3, and partly really diffuse from the decay of π° mesons produced in the collisions of primary cosmic rays with the interstellar gas, thus providing a link between γ-ray astronomy and the studies on the origin and the distribution of cosmic rays. Similarly, radio astronomy had already provided a link via the radio synchrotron emission of the ultra-relativistic primary electrons accelerated in the galactic magnetic fields; primary electrons were revealed for the first time by J. Earl in 1961[(11)]. It should be mentioned here that, although cosmic rays were discovered at the beginning of the century (~1914), it is only with the coming in operation of powerful particle accelerators that the interest in cosmic rays studies has gradually shifted toward their astrophysical implications, i.e. the sources and the acceleration mechanisms at work; the studies of the extensive air showers had shown that cosmic ray nuclei could be accelerated at extremely high energies ($> 10^{15}$ eV). Coming back to the γ-radiation, a re-analysis of OSO-3 data has also shown the detection of a background component of extragalactic origin. In the following decades the results from high-altitude balloons and, mainly, from dedicated satellites have demonstrated the importance of γ-ray astronomy for the studies of a variety of subjects: supernovae and SN remnants, nuclear gamma rays, AGNs, the distributions of cosmic rays in space, etc., and the well known phenomenon of the gamma ray bursts.

This brief summary of the main early achievements in these new fields, not to mention initiatives in the UV and infrared, is sufficient to outline the great excitement that pervaded the world of astronomical research in the 1960s.

The reaction of the astronomical establishment in Italy both in the observatories and in the universities to the bursting of the new astronomy was, with very few exceptions, almost non-

existent. One such exception was represented by Guglielmo Righini, then director of the Arcetri Astrophysical Observatory, who promoted the development of solar radio research in Arcetri first with a small radio telescope (an antenna with four helicoid elements) then followed by a 10m diameter parabolic reflector working at high frequencies (1965). The reason for this scanty interest in the new astronomy is rooted in the history of the Italian astronomy of the previous years that had seen a growing dominance of people most interested in positional and classical astronomy, rather than astrophysics, occupying the (few) chairs of astronomy in the universities and associated positions of directors of the Observatories spread throughout Italy. Of course, the disruptive difficulties connected with the pre-war political situation in Italy and the war itself certainly must have played an extremely negative role making the post-war recovery rather problematic.

2. The role of the physicists

Fortunately the Italian physics was recovering very well from the post-war situation. Students and collaborators of Enrico Fermi, Bruno Rossi and other physicists that left Italy during the fascist period played a central role in the reorganization not only of the physical studies but also of the main structures for the development of science, such as the National Research Council (Consiglio Nazionale delle Ricerche, CNR). The strong interest in nuclear and sub-nuclear physics lead to the foundation in 1951 of the National Institute for Nuclear Physics (INFN) which provided the physicists with an additional leverage, i.e. financial resources and basic research structures, that could also be employed more generally for studies of the physical world. In addition, Italian physicists maintained close connections with the international world of physics both in Europe and in the States. It is thus not surprising that a number of leading figures in Italian physics, particularly those who had been involved with cosmic ray research, got a keen interest in the new astronomy whose techniques were closer to the kind of expertise familiar in the physics labs.

Let me just briefly mention some of the key initiatives:

In 1959 Giampietro Puppi, who was holding a Physics chair at Bologna University and was director of the Physics Institute "A. Righi", promoted the development of radio astronomy with the aim of constructing a major radio telescope. For this purpose he obtained a sizeable grant from the Italian Ministry of Education. Marcello Ceccarelli, an elementary particle physicist then associate professor of Physics in the same institute, was put in charge of the project. He gathered around him a group of young researchers and technicians, notably among these Alessandro Braccesi and the late Gianfranco Sinigaglia, and in a matter of a few years (dedication in 1964) build what became to be known as the "Northern Cross" (Fig. 1), a radio telescope with a large collecting area (~ 30.000 m^2) working at a frequency of 408 MHz, with the main aim of making a contribution to the cosmological studies. It was an amazing feat for a research group that started from stretch.

Giampietro Puppi also promoted a research group in Bologna, lead by Domenico Brini, for the studies of X- and γ-ray astronomy and of cosmic rays.

The group lead by Giuseppe Occhialini, who hold a chair of Physics at the University of Milan, became involved in cosmic ray experiments for the detection of primary electrons and in γ-ray astronomy leading somewhat later to a deep involvement in the European COS-B mission for γ-ray astronomy.

Carlo Castagnoli, Physics professor at the University of Turin, in 1959 funded the Centre for Cosmic Physics (FISCOT) and developed the underground labs of Mt. Blanc and Mt. dei Capuccini and the lab of the Testa Grigia on Plateau Rosa for cosmic ray studies.

In 1960 Edoardo Amaldi, Physics professor at the University of Rome "La Sapienza", promoted a research group for cosmic rays research from balloons and for the studies of the solar wind-magnetosphere interaction in connection with the starting of ESRO (1963-64).

Puppi also convinced the astrophysicist Livio Gratton to return to Italy (1960) from the University of Cordoba (Argentina); Gratton, after a year spent at the University of Bologna, moved to the chair of astrophysics at the University of Rome "La Sapienza" and in 1962 established, with the support of Amaldi, the Centre for Astrophysics of the CNR in Frascati and started developing space research activities in the fields of planetology and X-ray astronomy.

3. The role of the CNR

The consolidation of the above initiatives was accomplished in the late 1960s by the CNR with the establishment of the following institutes (initially called 'laboratories'):

1968 Istituto di tecnologie e studio delle radiazioni extraterrestri (ITESRE - Bologna)
1968 Istituto di Cosmo-geofisica (Turin)
1968 Istituto di Fisica dello Spazio Interplanetario (IFSI - Frascati)
1969 Istituto di Fisica Cosmica e Tecnologie Relative (IFTCR – Milan)
1970 Istituto di Radioastronomia (IRA - Bologna)
1970 Istituto di Astrofisica Spaziale (IAS – Frascati)

It should be noticed that these institutes were established when Puppi, one of the founding father of the new astronomy in Italy, was president of the Physics Committee of the CNR. It should further be noted that the Istituto di Fisica Cosmica e Applicazioni all'Informatica (IFCAI – Palermo) was established much later (1981) by incorporating a detached section of the IFCTR and a Research Unit of the CNR in high-energy astrophysics under the leadership of Livio Scarsi.

For the coordination and financial support of the activities in the field of cosmic physics the CNR had already instituted (1963) the National Group of Cosmic Physics (GIFCO) and, somewhat later (1970), the National Group of Astronomy (GNA) for the coordination and support of activities in astronomy, inclusive of research units in the universities and observatories. These coordination groups have played an important role in the advancement of astronomical research in Italy. Thus by the beginning of the 1970s it was already clear that the CNR should have supported the development of the new astronomy, while optical astronomy would have been mainly supported by the observatories via the financing provided by the Ministry of Education.

To see how things developed I will briefly outline the most important steps that necessarily took place in the decades following 1970, again with reference to the main fields considered above:

a) As far as radio astronomy is concerned one should mention that the Istituto di Radioastronomia (IRA-CNR) grew both in staff and in new facilities. Two twin radio telescopes, 32m fully steer-able parabolic reflector each, came into operation the first one in 1983, close to the "Northern Cross", and the other one in 1988, close to the town of Noto in the southern tip of Sicily. These radio telescopes, able to operate up to a frequency of 23 GHz, became also a standard element of the European Very Long Baseline Network (EVN). In 1997 the Ministry of Education and Scientific and Technological Research approved the project of a new radio telescope, named the Sardinia Radio Telescope (SRT), a 64m fully steer-able parabolic reflector able to operate up to a frequency of 100 GHz, which is being constructed under the responsibility of IRA-CNR in collaboration with the Astronomical Observatory of Cagliari and with partial support from the

Sardinia Regional government; it will be placed on a valley in the Mt. Gerrei region (Sardinia) at almost 600m of altitude.

b) The development of X- and γ-ray astronomy was clearly dependent on resources available for space research. Aside from grants and financial support for astronomy projects of direct interest of, and financed by the European space organization (ESRO that subsequently developed into the European Space Agency, ESA), space research in astronomy has been essentially supported by the CNR up to the institution of the Italian Space Agency (ASI) in 1988. A major step forward in basic science could have only been made with the consolidation of a national space programme which, in broad terms, was characterized by the following events:

In 1970 the CNR established the Service for Space Activities (SAS); in 1980 the Italian government assigned to the CNR the management of the National Space Plan (PSN) as a "finalized project" and in 1982 the CNR was finally put in charge of the PSN for the years to come until the approval of the law which established ASI. Luciano Guerriero, a Physics professor from the University of Bari, became director of the PSN and first president of ASI. The important point here is that the law establishing ASI dictated that at least 15% of the ASI's budget should be spent for basic science according to the planning of a Science Committee composed of experts in the various fields of research. Unfortunately this safeguard for science, whose adoption was largely due to a personal involvement of Edoardo Amaldi, was cancelled years later (1998) by a new law that reorganized ASI and the ensuing negative effects are now perceived by the astronomical community.

During the CNR period a most significant step was taken with the approval of the first Italian space mission dedicated to astronomical research (1980-81). This was decided following a restricted meeting convened by the then Minister for the Coordination of Science and Technology Research, Hon. Giancarlo Tesini (as I remember the attendees included, among others, Giampietro Puppi, at that time advisor to the Finance Minister, Giuseppe Colombo, Luciano Guerriero and myself as president of the Physics Committee-CNR). The decision was not easy to arrive at not only for the financial implications, but also because there were political positions in the Parliament opposing any involvement in space missions for astronomy outside the science mandatory programme of ESA. Following a call for proposals issued by the PSN, the proposal named "Satellite per l'Astronomia X (SAX)" was selected leading many years later, after a number of important modifications and internationalisation of the project, to the launch (1998) of the *Beppo*SAX mission whose discoveries are all well known. Four of the astrophysical institutes of the CNR (ITESRE, IFCTR, IFCAI, IAS) were heavily involved in the study of the mission and in the realization of the instruments on board the satellite.

It would certainly be of interest to examine in greater detail how the involvement in the new fields of astronomy developed in all research institutions after 1970, but this is very much outside the time interval to which this meeting is dedicated.

4. Concluding remarks

What I have tried to show is that at least a few disciplines of modern astronomy, namely radio astronomy and X- and γ-ray astronomy, are deeply rooted in the CNR and were promoted by several physicists with a broad view on the new ventures in the investigation of the physical world at a time when the great majority of the Italian physicists where almost exclusively interested in particle physics. This history also shows the role of the CNR as a national research institution able to foster the growing of new perspectives in the investigation of nature. It is rather worrisome that a very recent reorganization of the scientific institutions in Italy may provide a too narrow jacket and

a rigidity that may completely curtail the capability of fostering new and unpredictable ways of research.

The role played by the physicists interested in astrophysics and by the CNR had a profound effect in the renewal of Italian astronomy. An increasing number of university positions were occupied by scientists interested in the new fields of astronomy, likewise research groups in the observatories became interested in the new windows for exploring the universe, which had been open with space research. As a sign of the changing scenario of Italian astronomy it may be recalled that it was finally decided to participate in the European journal "Astronomy & Astrophysics"; again, this was formally carried out by the CNR (1972) and the cost charged on the yearly budget of the Physics Committee. It was also decided that the old, glorious journal "Memorie della Società Astronomica Italiana", run by the Italian Astronomical Society (SAIt), should not be suppressed, but should be essentially dedicated to the publication of review articles and conference/workshop proceedings.

The role of the CNR and of its Physics Committee was also of key importance in reshaping optical astronomy. In 1978 Amaldi (then president of the Physics Committee–CNR) and the author (then representative of astronomy in the same committee) visited Amb. Sergio Romano, then director of the Cultural Department of the Ministry of Foreign Affairs, asking his intervention to promote the participation of Italy in the European Southern Observatory (ESO), the European organization that was established in 1962. The actions that were taken following this visit laid down the seeds that finally debouched into the approval by the Italian Parliament of the law for Italy to become a member of ESO (1982). It is interesting to notice that, as a result of the lengthy discussions that took place in the year preceding the approval of the law, the report illustrating the law itself contained an explicit mention of a world class national telescope for the northern hemisphere to provide Italian astronomers with a complete set of instruments to access optical observations of the all sky following the participation in ESO. To my knowledge this is the first time that the long sought dream of a national telescope appeared in a document at the parliamentary level. Clearly the Italian astronomers had missed the opportunity to join ESO at the time that this organization was established; the all history of Italian astronomy might have taken a different course, if that had happened.

The changing situation of astronomical research was finally perceived also by the Ministry of Education that set up a committee to advise on the reorganization of the observatories. This lead to the approval of a law (1982) instituting the Council for Astronomical Research (Consiglio per le Ricerche Astronomiche – CRA), an advisory body of the Minister, and a redefinition of the scope, staff, organization and so on of the observatories. No doubt this had a profound effect on the revitalization of the research done in the observatories and, among other things, the CRA promoted the two major projects for optical astronomy: the National Telescope Galileo (TNG) and the participation in the Large Binocular Telescope (LBT), a major international effort to build the largest and unique optical telescope on a single mount. I am not going to dwell here with the important role played by the National Consortium for Astronomy and Astrophysics (CNAA) set up by the observatories in 1996 and with the institution (1999) of the National Institute for Astrophysics (Istituto Nazionale di Astrofisica, INAF) that has drastically changed the organizational structure and perspective of astronomical research in Italy, except to say that all this is essentially a consequence of the law instituting the CRA in 1982.

Thus, the new branches of astronomy that surfaced around the year 1960 have had far reaching consequences on the development and organization of astronomical research in Italy all the way down to these days. This is as it should be because the research activity has been so alive and so much intertwined at the international level that every step forward has been closely linked to the pre-existing situation. Under these conditions the history cannot simply be the sum of static frames

marking the list of events, but it should be viewed as a dynamic process in which, no doubt, the personal judgement may introduce elements of subjectivity. Therefore, having focussed the attention on what actually happened in the years around 1960, it has been natural to outline some of the main developments that took place as a result of the forces set in motion in those years.

Obviously this presentation is only a sketchy picture of lines of events that I believe are closely interrelated. It is perhaps time to describe in detail the history of Italian astronomy of the past forty years, 1960-2000, and this for two good reasons: firstly, the relevant documentation is very much spread about in different institutions and it may not be easy to dig it up; secondly, relevant pieces of information are not to be found in any written document, but are memorized in the minds of peoples that played an active role in the transformation of astronomical research and it is better to collect this information before it's too late.

References

(1) Jansky K., Proc.Inst.Rad.Eng., 20 , 1920, 1932; 23, 1158, 1935
(2) Reber G., Astrophys. J., 91, 621, 1940; 100, 279, 1944
(3) Muller, C.A. & J.H. Oort, Nature, 168, 357, 1951
(4) Ewen, H.L. & E.M. Purcell, Nature, 168, 356, 1951
(5) Baade, W. & R. Minkowski, Astrophys. J., 119, 206, 1954
(6) Hazard, C., Mackay, M.B. & A.J. Shimmins, Nature, 197, 1037, 1963
(7) Schmidt, M., Nature, 197, 1040, 1963
(8) Penzias, A.A. & R.W. Wilson, Astrophys. J., 142, 419, 1965
(9) Hewish, A., Bell, S.J., Pilkington, J.D., Scott, P.F. &R.A. Collins, Nature, 217, 709, 1968
(10)Giacconi, R., Gursky, H., Paolini, F. & B. Rossi, Phys. Rev. Lett., 9, 439, 1962
(11)Clark, G.W., Garmire, G.P. & W.L. Kraushaar, Astrophys. J. Lett., 153, L203, 1968
(12) Earl, J.A., Phys. Rev. Letters, 6, 125, 1961

Setti, G., *1960 and thereabout: the New Astronomy (Notes for a history still to be written)* in "Cento Anni di Astronomia in Italia: 1860-1960", Atti dei Convegni Lincei, Bardi Ed.: Roma, 405-416, **217,** 2005