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My researches at the infrared doors

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Abstract. As a historical and biographical introduction to this Conference, I give here a brief review about my studies in infrared astronomy. I begun making regular observations in this unexplored (at that time) field moving from the wavelengths just beyond the visible, where I discovered, for example, the galaxies then named Maffei 1 and Maffei 2, located in the Zone of Avoidance. The analysis of the material thus collected, mainly aimed at studies on long period variables (LPVs), produced a series of new and hardly predicted results. Further important developments of my researches in infrared are now expected from the ongoing development of an Antarctica telescope for the mid-infrared bands. These bands were an almost unexplored range of the spectrum only a few years ago: now the researches discussed in this meeting show how many new fields of study have become active in them.

Key words. history of astronomy – biographies – infrared: stars – stars: LPV – infrared: galaxies – galaxies: individual (Maffei 1, Maffei 2, IC 342/Maffei 2 Group)

1. Introduction

Astronomical researches have always fascinated, me in nearly all the fields: from the Sun to galaxies, from comets to nebulae and stars. In particular, the study of the celestial bodies at infrared wavelengths was almost a pre-destination. Everything began with my degree thesis at the Observatory of Arcetri. Professor A. Colacevich had carried from United States some plates of the *Selected Area 8* (including the star γ Cas), obtained with the Schmidt telescope of the Warner and Swasey Observatory (Cleveland). With such an instrument, and using plates I - N (+ filter Wratten 89), J.J. Nassau in 1948, begun the sub-classification of the lowest temperature stars, which he found through very low dispersion spectra (Nassau & van Albada 1949). The sub-classification criteria for the "cool" red stars were still under definition, for stars of types M and S and, above all, for stars of types R and N. Attempts were being made to unify them under a single new class that, showing all bands of the carbon

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Fig. 1. Paolo Maffei around 1975.

compounds (C_2, CH, CN), was tentatively called "C" class. These attempts were not crowned by much success, as anyone working in late type stars now knows! The examination of spectra (of only 0.6 mm length on the plates) allowed me to find 165 stars of spectral type M, 9 of type C and 1 of type S. This research contributed also to the improvement of the classification criteria, in collaboration with Prof. Colacevich. Unfortunately, he was named director of the Naples Observatory before the end of my bachelor thesis and passed away prematurely.

Since then I directed my studies to Solar physics for some years. At the end of 1955, when I was appointed assistant of Astronomy at the Bologna University, I returned to researches in the nocturnal sky, with the Zeiss 60-cm reflector of the Loiano Station. Following indications by L. Rosino, I began to photograph clusters of galaxies (in the search for supernovae), globular clusters, novae, various classes of nebulae, variable stars in nebulae and comets. These fields were all rather new, and interesting for me, but I was especially attracted by comets and by the first stages of stellar evolution, through studies of variable stars in nebulae, flare variables, Herbig-Haro objects and small nebulae, either associated to stars or not. The study of comets attracted me not only for the fascination inspired by their unexpected appearence and unpredictable behaviour, but also because, at that time, they were the only probes for the study of interplanetary materials and of the effects of the solar wind at different distances from the Sun. I continued these studies with success, at Asiago (Wurm & Maffei 1961) and resumed them many years later, in occasion of the Halley comet passage in 1986 (Cosmovici et al. 1993), though this is not the adequate place for such a discussion.

2. Pioneering infrared techniques and observations with them

I became fascinated by the first stages of stellar evolution through the study of NGC 2264, in which I collected and studied all the material of Loiano while Rosino, promoter of the research, examined together with Grubissich the material obtained at the 120 cm reflector in the Asiago Observatory. Also after the publication of the abundant results (Rosino et al. 1957) I continued the research on this cluster and around it at Loiano, Asiago and Hamburg (Maffei 1966a,b), this time pushing the observations outside the blue band.

Examining the first published photographs of the Palomar Sky Survey I decided to prepare an atlas-catalogue of all the merging galaxies and I began to photograph them with the Loiano telescope. In 1958, at the IAU Meeting, I knew that a similar work was in advanced progress by Vorontsov Velyaminov. I suspended this research and published the results obtained (Maffei 1960), the most important of which was the discovery of polarized light from the jet of NGC 4676.

In the first months of 1956, I was able to hyper-sensitize the infrared Eastman emulsions I-N through the immersion in a solution of NH_3 at 5%, for 3 - 5 minutes. After the first attempts I found that the I-N treated in this way and combined with a Schott filter RG5, allows one to achieve in 10 minutes of exposure the same results of a normal I-N+RG5 in 60 minutes. Considering that the limiting pose for the hyper-sensitized I-N, applied to the same instrument, could extend until 50 minutes, I was astonished from the enormous gain obtained in the detection of weak infrared fluxes. The hyper-sensitizing process was rather boring and painful because the operations of immersion in the NH_3 solution, of washing and drying, had to be performed watering in a complete dark room and avoiding any thermal source. Moreover the plates had to be used within 24-48 hours. This monk-like work was however well repaid. By August 1956 I used to exploit this technique on a normal basis, in order to exploit the very near-IR (from 6800 Å to 8800 Å), just beyond the H_α line. This extension was sufficient to reveal new features of the sky, due to the increased power of penetration and the access to the coldest objects observable at that time.

Fig. 2. Paolo Maffei during this conference.

Already with the first tests I had the impression to open a window on a new panorama in astronomy. In the northern zone of the Trapezium (Orion nebula), I saw, richer and more extended, the cluster of red or reddened stars, most of them variables, that Rosino found with the non-treated I-N plates, appearing from the nebular background, strongly weakened for the removal of the H_α emission. The various planetary nebulae, that I had already photographed in other colors, disappeared with the new technique, except the one in the Lyra. One unexpected surprise occurred for the nebula M17: photographed in H_α light it appeared, as a rule, more intense than in the blue, so I was very surprised in finding that also in the infrared it appeared more luminous and with a different structure with respect to blue plates (of course I used in both cases the same limiting pose). But these were not the greater surprises.

Continuing the comparison of images obtained in the traditional colors and in emission lines with those in the infrared, I found something so amazing that induced me to change my research guidelines. In order to explain my wonder it is necessary to go back to the end of the Thirties, when C. Hetzler, first in the Allegheny Observatory and then in the Yerkes observatory, began to photograph the sky in the infrared with the Eastman I-P emulsion and a Wratten 87 filter. With this combination he isolated the spectral zone around 8500 Å, in which the continuum was not disturbed by TiO bands. Analyzing the reddest stars in eight fields of 50 square degrees, Hetzler discovered and catalogued the first "infrared stars" (i.e. stars whose blue and infrared magnitudes differed by more than 5^m). In any case no infrared indices (visual to 8500 Å) greater than about 9 or 10 magnitudes were found (Hetzler 1937). He carried on also a study of the infrared curves of representative long-period variables (Hetzler 1936), and from the light curves, plotted homogeneously both in the infrared and visual for about thirty variables, he found that the mean infrared-magnitude range of variability was 2.5^m, compared to 5.0^m in the visual band.

Unfortunately Hetzler's works were considered no more than an interesting curiosity, and of its results only the small amplitude of the infrared light curves were considered, which fact discouraged astronomers to adopt the new technique for observations of long period variables (LPVs).

In the summer of 1957, during my research on diffuse nebulae that I photographed with liquid filters at narrow pass-band prepared by K. Wurm, I obtained an image of the nebula M20 in the line H_α. The structure of the nebula appeared with a clearness and contrast never obtained before. Comparing the plate with another one, carried out in the same conditions exactly a year before, I noted the appearance of a star just at the edge of an hydrogen filament that ended near the multiple star at the center of the nebula. The position of the new star induced me to consider it a variable of pre-main sequence. In the attempt to discover other variable stars of the same early types, I began to photograph systematically this field in the infrared, in which the star was well visible and the nebular luminosity almost cancelled. After some years of observations, first at Loiano, and then at Asiago (where I moved) I discovered 9 variable stars. But I noted than only the first one, found by chance, was clearly a variable of pre-main sequence. The other stars were all long-period variables, with amplitude of variability up to 7^m, well above the differences of 1-2 magnitudes found by Hetzler, that discouraged variable star observers (Hetzler 1936). These were important indeed, because the Mira-type variables with advanced spectra have the maximum of emission towards the IR bands, due to the low superficial temperatures, and therefore infrared is the only band in which the main part of them can be discovered and observed well.

Comparing the observation technique by Hetzler with mine, I found the explanation of the strangeness of my results. The remarkable amplitude could be explained with the fact that Hetzler, with his combination of emulsion-filter, had excluded the bands of TiO, and the variations of luminosity observed by him were due only to the continuum, rather small for the limited temperature variation. The combination adopted by me (I-N+RG5), instead, embraced an interval of around 2000 Å (from 6800 to 8800) in which there are numerous molecular bands that form and dissociate easily, during a variability period and change the atmosphere transparency and then the observed magnitude. This is so because the dissociation temperatures of the corresponding molecules fall into the variation range of the temperature of these star atmospheres. At the end of 1965 the number of Miras that I found increased to 15. I already saw two important results from the introduction of my infrared technique: the icrease of the Mira-type number and the fact that 9 of the new variables showed periods longer than 400 days. Since Miras in the *General Catalogue of Variable Stars*, with period longer of 400 days, were only 7.7%, while in this case they increased to 60% of the sample, it followed that the cooler Miras were varying at longer periods.

In the meanwhile I extended the research in infrared also to pre-sequence objects. I observed the regions centered on NGC 1999 (Maffei 1963b) and the star 49 Ori (Maffei 1963c) achieving new and interesting results on the increased number of variables, on the objects Haro 13a, Haro 14a and Haro 249, and the discovery of a completely different behavior in the variability of star VY Mon observed in the blue and in the infrared. I published a synthesis of these first results (Maffei 1967), but I understood also that in order to achieve a systematic search, I had to compare the outcomes in the blue (the color in which the greater part of the photographic surveys was performed at that time) and in the infrared, in more regions, with wide field (Schmidt) instruments. This could be useful also to have an idea of the changes in the number of variables of other types, observing in the old colors and in the photographic infrared. I started to choose the fields at Hamburg, where I obtained large field spectra with the Schmidt telescope, that had the larger objective prism in the world at that time. I included the field of IC 1805 and IC 1848, near the Galactic anticenter, rich of emission nebulae, clusters, stellar formation regions (my old love) and dust clouds.

Finally, in 1967, I started a program of systematic photometric observations (the adverse sky conditions in Hamburg did not allow it) with the new Schmidt of 90/65 cm installed at the Asiago observatory. This new instrument placed me again in the conditions of the Loiano reflector, having the same focal length, an useful diameter slightly bigger, but with a field area 25 times the former. The extensive program of blue-infrared research involved the observation of all variable stars in six star fields. Of course I had included the field of IC 1805 and IC 1848, in which I had obtained spectra and blue photographs with the large Hamburg Schmidt telescope few years earlier. My technique consisted in the exposure of set of two plates to the same field: one in the visible region, in the blue; one in the invisible radiation, the infrared. Each set of plates required approximately 40 minutes. I had to work during most of the night, as I had to photograph several star fields, and I had to repeat the exposures for many nights... and years, to study these variable stars, most of them varying with very long periods.

3. The discovery of the galaxies Maffei 1 and Maffei 2

During the night of September 29, 1967, I exposed the first two blue-infrared plates: a Kodak l03a-0, sensitive to wave lengths between 2500 and 5000 Å and an I-N plate hyper-sensitized with an RG 5 filter sensitive in the range 6800-8800 Å (infrared). On the following day I noticed with great surprise an object which was strangely very bright in the infrared and invisible in the blue. I realized at once that it was an extraordinary object. Most celestial objects, with the possible exception of very cool stars, are bright at all optical wavelengths including, of course, blue or intense at radio wavelengths and sometimes both. However, this object, known to be of non-stellar type because of its fuzzy image, seemed to me invisible at optical wavelengths. Yet it emitted very strongly in the infrared. I was quite puzzled about the true nature of this strange object and I looked for it on the red photograph of the Palomar Sky Survey. My object was not visible in the blue photo of the survey, in accordance with my observation. But I found it, to my surprise, in the red photograph. It was a very faint spot.

Having found the object on the red photo, I considered the possibility that the red image was due essentially to a sizeable contribution from H_α line emission. I exposed a plate in red light and noticed that the brightness of the object increased from the red to the infrared. Now, with my new information, I was able to exclude the H_α contribution by the following argument. Most nebulae are very bright in the red region of the spectrum, mainly due to the emission of the H_α line of hydrogen. If we were able to photograph in the near infrared in such a way as to exclude this line, a celestial object would only remain visible due to the continuum spectrum or to the emission lines produced by elements other than hydrogen. In the case of nebulae, both these contributions are generally very small and the nebulae are then very faint in the infrared. The behavior of my object was just the opposite. There are some cases in which a nebula is also bright in the infrared. For instance (see above) I had found, some ten years before, such a case in the nebula M17. However, M17 was much brighter in H_α than it was in the infrared.

The new object found in the field of IC 1805, almost invisible in the blue, was visible in H_α but was much brighter in the infrared. It forced me to think about a kind of continuum emission which becomes progressively stronger with increasing wavelength. Hence, it should be even stronger for radio wavelengths. I searched for the presence of radio sources in the field; the nearest and strongest, 3C 69, was too distant to be in any way related to the object.

In discussing with many colleagues my discovery, I generally encountered dignified indifference. Our scientific world is too specialized for something new to be of interest, as at the time of discovery one does not yet know in which field to place it.

Only two colleagues, both from the Laboratory of Astrophysics at Frascati, Humberto Gerola and Nino Panagia, urged me to carry on with this research. At that time they were engaged in a study of the mechanism of continuum emission through the two-photon process, and they may have thought that my discovery was, in some way, related to that mechanism.

In the first period, I thought I was dealing with a T-Tauri-like object. I already found that one such object (Haro 13a) was very bright in the infrared, and showed at one extreme, a variable “star” which was also infrared. But the new nebula showed no source responsible for the illumination. Then I began to think that the object might be something highly obscured and reddened, but still refrained from publicly favoring either of these alternatives (an highly obscured and reddened object or a T-Tauri–like nebular object), so that the investigation could be developed in all possible directions. I had not the necessary equipment (far infrared photometers and slit spectrometers) in Italy to proceed with the investigation, as I wished to do, then I published the available results (Maffei 1968). It was while I was preparing this note, that I found the second object, and at first I was a bit annoyed. Two new and extraordinary objects were beginning to be too many! Nevertheless, I again searched the whole field for other similar objects, but this further search was fruitless.

It was now important to find out if the objects emitted strongly at radio frequencies, so I also informed the radioastronomy group of Bologna of the discovery of these two objects. Unfortunately, at this time the radiotelescope of Medicina was in the process of being revised and recalibrated. It was only toward the end of 1969 that Gavril Grueff explored the field with the Medicina facility and, in a letter of December 1, 1969,

Fig. 3. 2MASS (Two Micron All Sky Survey) Atlas image of the nearby giant elliptical galaxy Maffei 1, lying only about 4-5 million parsecs (Mpc) from our Galaxy. It was initially detected in the near-infrared as an anomalous source in 1967 by Paolo Maffei (Maffei 1968), that discovered also the apparently nearby object Maffei 2. Several galaxies were discovered around these two. The so-called IC 342/Maffei Group of galaxies near Maffei 2 actually consists of 16 known or suspected members (Buta & McCall 1999; Karachentsev et al. 1997) and is one of the closest groups to the Milky Way, and probably the closest group to M31 (Andromeda). The Maffei Group lies in the plane of the Milky Way and the reddening and extinction from the dust of our Galaxy make them almost invisible at optical wavelengths. This highlights the importance of the near infrared, as a window on galaxies behind the Milky Way disk in the so-called “Zone of Avoidance”, where they are hidden due to Galactic dust. This image was taken with the northern facility of 2MASS in 1997 October, and illustrates that in the near infrared the effects of obscuring dust particles are greatly diminished, revealing the true brightness and extent of this extragalactic neighbor.(Atlas Image mosaic courtesy of 2MASS/UMass/IPAC-Caltech/NASA/NSF).

Fig. 4. 2MASS Atlas image of the nearby barred spiral galaxy Maffei 2, which is located near the Galactic Plane, at galactic longitude $l = 136.50$ and latitude $b = -0.33$, and suffers from about 5 magnitudes of visual extinction. As such, it wasn't recognized as a galaxy until it was initially detected in the near-infrared as an anomalous source by Maffei (Maffei 1968) and its morphological type was identified by Spinrad et al. (Spinrad et al. 1971). Maffei 2, at a distance of about 5 Mpc, appears near its elliptical companion, Maffei 1. Although its gas kinematics are consistent with those of other barred galaxies, Maffei 2 in the infrared, radio continuum and H I emission appears markedly disturbed, resembling to the class of starburst galaxies. The structural asymmetries, as well as the nuclear starburst, are possibly driven by an ongoing merging with a small satellite companion galaxy (Hurt et al. 1996, 1993). (Atlas Image mosaic courtesy of 2MASS/UMass/IPAC-Caltech/NASA/NSF).

informed me that he had found the object 2 to be radio-loud, while the object 1 was radio-quiet. In the same letter he stated that, in his opinion, based on the Palomar Sky Survey, the two objects were obscured galaxies. Object 2 might even be a spiral galaxy! These remarks were never published and I enjoy now in remembering that he was the first one to suggest that the two objects might have been two galaxies. This version began to persuade myself also.

Toward the end of August, 1969, I received a letter from Robert Landau, a graduate student at the University of California at Berkeley, who wanted to carry on with the investigation and wished to know if I had obtained any new results in the meantime. I answered that I had not the necessary instruments: no telescopes were available at the Laboratory of Astrophysics at Frascati, where I worked, and that the discovery of the two objects, was made while I was a guest observer at the Observatory of Asiago. I therefore encouraged him to proceed with the investigations.

Then I received the unofficial news, that the research begun by Landau, carried on the Mount Palomar and Lick observatories and the successive research done during 1970, confirmed that the two objects were indeed galaxies. Among the most important characteristics known at present time on these sources, after hundreds of studies about them, are that the galaxy named Maffei 1 is a giant elliptical galaxy, strangely radioquiet, while the Maffei 2 is a radio-emitting starburst galaxy. Both are the nearest to us of their class. Recent observations revealed 14-16 galaxies about Maffei 2, called IC 342/Maffei Group. According to a very accurate research of Buta & McCall (1999), if not for the heavy extinction, the two Maffei galaxies would be among the ten brightest galaxies in the northern sky.

No one had seen these galaxies before because, until that time, no one had used systematically the method of comparing blue and infrared plates which I used, finding the two objects. Even when I used the technique of blue and infrared observations mainly to study the behaviour of variable stars in the two colors, I always examined the sets of plates looking for other objects. I learned on the importance of this comparison also with the nebula M17, the object Haro 13a and an infrared nebula in NGC 2264, found jointly with Rosino and Grubissich, which fifteen years later was found to be a strong emitter in the far infrared (Allen 1972). In this case I feel that the most important consequences, connected with the discovery of the two galaxies, are a better knowledge of the outer zone of our local galactic system (the Ursa Major-Camelopardalis system), and the triggering for the seek of galaxies in the Zone of Avoidance, using both the radio and infrared observations.

4. The researches on LPVs

When I found the two galaxies, the blue-infrared observations for the search and the study of the variable stars were at the beginning. The Miras that appeared in the infrared had the longer periods, then their study required groups of observations over many years. Therefore I continued, and I'm continuing still today, the study of the collected material. Also this research has given important results.

As said above, starting from 1959, red and infrared plates were collected more and more systematically with different instruments. These observations showed that the infrared light curves appeared more regular, that these obtained previously, in the visual or in the blue light. Therefore I obtained, for the long period variables (LPVs), the first phase light curves (Maffei 1966b), which in most of the cases, appeared very regular over some period. After this preliminary but very suggesting result, a finalized research on LPVs was started in the summer 1967, when the Schmidt telescope 90/65 cm of the Asiago Observatory began to operate. In the 1970's some other astronomers began the IR observation of the LPVs, (e.g. Rosino & Guzzi 1978; Rosino et al. 1976). The researches were also extended through observations in the new infrared "colours" J, H and K.

Nevertheless the finalized research started in 1967 by me was different from those cited above, in the method, the purposes, and in the results obtained. The main characteristics of these observations are the following:

a) In order to obtain a good sensitivity to variability, by means of the large change of magnitude due to the presence and opacity of absorbtion bands with small variations of temperature, the whole spectral range from 6800 to 8800 Å was covered.
b) As a rule, together with every infrared plate, a blue one was taken. This was decided with two purposes. The first was to estimate the increase of the variable star number observed in the photographic infrared, in comparison with a similar survey obtained with blue plates. The second was to compare the behaviour of the light curves, for the variables which appeared in both colours.
c) To check the constancy or not of the shape of the light curves and of the periods, the observations were repeated various times during the space of some 30 years: the longer period covered until now in the infrared. In the affirmative case, it was possible to fix with accuracy the value of the period; alternatively, I examined the type of the changes, and an explanation was attempted.
d) With the aim to reach results of statistical and evolutionary interest, four fields were chosen, all near the galactic plane but at different longitudes. The fields selected were the following: one centered at (1900.0) $\alpha = 18^h 14,6^m \quad \delta = -14°50'$, including M16 and M17 ($l = 16°$); a second one centered at (1950.0) $\alpha = 2^h 40^m, \quad \delta = 60°30'$ ($l = 135°$), and two centered on the stars γ Cygni ($l = 78°$) and γ Cassiopeae ($l = 124°$) respectively.

The research was made also with the aim of discovering variable stars different from LPVs. Three lists were compiled. After the first already mentioned, the second and the third field were published by Maffei (1975a, 1977), Gasperoni et al. (1991). On the whole, 312 variables were numbered, till now.

The researches in the field containing M16 and M17 are now almost complete (see also posters in this conference). The

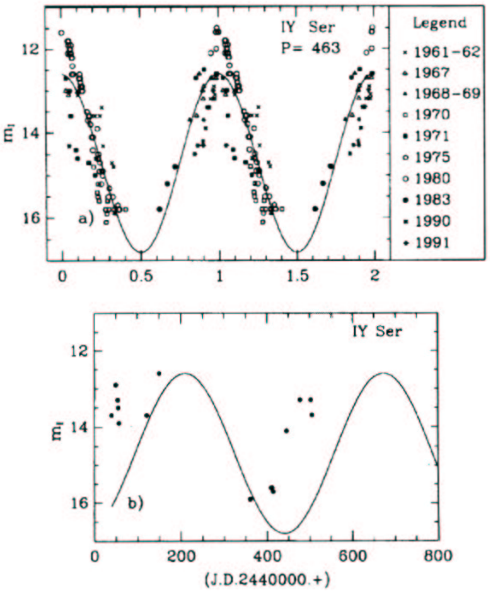

Fig. 5. Upper panel: phase light curve of variable IY Ser from 1961 to 1991 with a sinusoidal best-fit superposed (Maffei & Tosti 1995). The points attributed to rapid variations are not drawn. Lower panel: rapid variations observed at JD=2440053. The amplitude is 1 magnitude in I. Assuming as reference the sinusoidal fit to the light curve, a larger amplitude (about 2.6 mag) may be inferred. The point starting at JD=2440409 could be also associated with other rapid variations (reproduced by permission of the AAS).

updated characteristics of all the variables, their coordinates and the finding charts are given in an Atlas which reports phase light curves for 176 LPVs observed in the field (Maffei & Tosti 1999). They represent the majority of the infrared variables found in the three fields till now scanned. The results obtained in this field confirm the very strong increase of the number of LPVs (Mira and SR) when the observations are made in the near infrared. Moreover the most frequent period of these new infrared LPVs, appear to be some 100 days longer than that of the LPVs discovered in the direction of the galactic center, by means of the observations in B and V light.

An interesting discovery was made during the first researches in two fields. I found that some stars appear variable if observed in infrared radiation and constant in blue light (Maffei 1975b). The most likely explanation is that the phenomenon is due to a double star: a blue one, constant, and a red giant variable of the Mira type.

Another strange, not yet solved problem, was showed by some LPVs. In the summer of 1974, during a preliminary study of the numerous variable stars discovered on the infrared plates collected in the field of M16 - M17, I found abrupt changes of the I magnitudes in the light curves of few LPVs. I found especially that some of them seemed to show sudden brightening with an I amplitude less than a magnitude, and a duration of a few days. Moreover, comparable weakening also seemed to be taking place. These rapid variations were sudden and of short duration (2 days - 25 days) as compared with the period of the variables (200 days - 530 days) in which they occured. The lack of consecutive and closely spaced observations and the importance of testing the phenomenon, suggested me to carry out more frequent observations and a large comparison with all infrared LPVs, found in the field during the same research. The new observations were obtained mainly during 1980 with the Schmidt telescope of the Catania Astrophysical Observatory, favoured by the latitude, the altitude and a remarkable continuity in clear sky nights. The second target was reached through a long study of all the LPVs of the field (182) patiently carried out with Dr. Gino Tosti. The Catania's observations confirmed that these phenomena do occur. The general study showed that they are confined only to some of the LPVs observed, in which they appeared often more than once (Maffei & Tosti 1995). These are the main results obtained by me in 30 years, and for other 10 years with the precious collaborator Gino Tosti, through the exploration of the sky in a band only just tested before, but that subsequently has known a great development, towards more advanced wavelengths, at which the scientists now observe from the ground and from the space.

In an attempt to extend my explorations to wavelengths until 30-40 μm, from the 1990 I proposed to PNRA with Tosti and some colleagues of Frascati and Turin, the development of a robotic telescope to be installed in Antarctica. After more than a decade of job during which the instrument was built (Busso et al. 2002), the development of the plan is at risk to be entangled in the meshes of an obtuse bureaucracy and economic difficulties. Never mind! I will continue my researches in the usual band, just over the visible and on the material laboriously collected by me, hoping that it could reserve still some satisfaction for me, and further contributions to the knowledge of the cosmos.

In any case, I need to say that a great joy has been given to me, during this Convention, by many speakers who declared, publicly or privately, to have been addressed to the astronomical research by the reading of my books. Their results and projects, presented here, are the object of my esteem and admiration. And the feeling you all gave me, of having pushed in some way bright young colleagues towards such new and prestigious goals, is the best gift I could receive. In fact, I am firmly convinced that their new enthusiasm for the science of the skies is much more important than any personal contribution I might have given to astronomy with my researches.

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