Il Seminario ESA

Mattina del 4 dicembre 1987: l'aula A dell'Istituto "Antonio Garbasso" in Arcetri è affollata dai fisici del Dipartimento di Fisica, dell'Osservatorio Astrofisico, dell'Istituto di Astronomia, dell'INFN, del CNR. Sono presenti anche numerosi amici di Giuseppe Occhialini. Mentre numerosi studenti affollano il 'loggione' dell'aula a gradinata, molti altri assistono al Convegno nell'attigua aula B, in collegamento audio e video. Presiede la riunione il Prof. Paolo Blasi, direttore del Dipartimento.

Paolo Blasi [1]

È certamente un grande onore per il Dipartimento di Fisica dell'Università degli Studi di Firenze, ed è un privilegio per me, in qualità di suo direttore, avere la possibilità ed il compito di dare il benvenuto a tanti amici e colleghi, che sono qui presenti oggi e che hanno lavorato in questo Dipartimento molti, molti anni prima che io ed i miei colleghi più giovani ci venissimo come studenti prima e come docenti poi.

Come sapete, in questi giorni si sta svolgendo, presso la sala Brunelleschi dell'Ospedale degli Innocenti in piazza Santissima Annunziata, una mostra dal titolo "Dall'infinitamente grande all'infinitamente piccolo", organizzata dall'Istituto Nazionale di Fisica Nucleare sulle attività della Fisica del nucleo e delle particelle elementari, che si svolgono in Italia ed in particolare a Firenze, o comunque condotte da parte di fisici che afferiscono al Dipartimento o alla sezione INFN di Firenze.

In questo contesto, l'Agenzia Spaziale Europea, l'Osservatorio Astrofisico di Arcetri ed il Dipartimento di Fisica hanno voluto organizzare questa giornata, sia per rievocare gli inizi dell'attività scientifica spaziale in Europa, inizi che hanno visto come protagonisti alcune delle persone qui presenti, basti ricordare Edoardo Amaldi, Giuseppe Occhialini, Bruno Rossi, sia per ricordare il ruolo importante, anche se forse non abbastanza conosciuto, che ha avuto Arcetri nella nascita e nello sviluppo della Fisica Nucleare in Italia. Ne sono qui testimoni Gilberto Bernardini e Daria Bocciarelli, e l'allora studente Manlio Mandò.

Ritengo che l'attuale importante ruolo che i fisici fiorentini hanno conquistato nel campo dell'Astrofisica, della Fisica Nucleare, della Fisica delle Particelle, nasca anche da questa tradizione storica ed è quindi ancora più opportuno che noi più giovani possiamo conoscere e riflettere sui

[1] Il Prof. Paolo Blasi è stato direttore del Dipartimento di Fisica dal novembre 1985 al novembre 1988.

valori che questa tradizione storica ci tramanda, ascoltando la viva voce di alcuni tra i principali protagonisti di questa tradizione.

Pertanto questa giornata vuole essere una giornata di scambio di esperienze e dunque un'occasione unica di riflessione.

Comincerà con una relazione del Professor Lüst, direttore generale dell'ESA, che ringrazio insieme agli amici dell'ESA che sono voluti venire a Firenze in questa occasione. Successivamente ci sarà una tavola rotonda a cui parteciperanno i protagonisti della Fisica in Arcetri degli anni '20 e degli anni '30.

Lasciatemi dire anche qualche parola in inglese per i nostri ospiti.

In the framework of the exhibition organised by INFN in Florence, whose title is "From the infinitely large to the infinitely small", the European Spatial Agency, the Astrophysical Institute of Florence and our Physics Department have organised this meeting. Our aim is to recall the first steps of the scientific space research in Europe, and some people here gave an important contribution to these first steps, and to hear how Nuclear Physics developed in Arcetri in the 20s, directly from some of the main actors of that time: people who have accepted to come here, and we are very grateful to them. We would like also to express our thanks to Prof. Lüst and to his friends from ESA who will speak about the beginning of the scientific space activity in Europe.

I will give now the chairmanship of the session to Professor Noci, who will direct the first part of this meeting.

Giancarlo Noci [2]

Prima di tutto voglio associarmi, a nome dell'Istituto [3] di Astronomia e dell'Osservatorio Astrofisico di Arcetri, al saluto e al benvenuto. Ritengo che questo saluto sia particolarmente importante perché è proprio all'Osservatorio, che la Fisica fiorentina degli anni '20 e '30 trovava il suo momento di coagulo nel famoso Seminario che era diretto da Giorgio Abetti.

A questo punto io invito il professor Lüst, direttore generale dell'Agenzia Spaziale Europea, a presentare la sua relazione. Seguirà poi la relazione del professor Bonnet, attuale direttore dei programmi scientifici dell'Agenzia Spaziale Europea.

[2] Il Prof. Giancarlo Noci è stato direttore dell'Istituto di Astronomia dal 1985 al 1988.

[3] L'Istituto di Fisica si trasforma in Dipartimento già nel 1983, mentre invece l'Istituto di Astronomia, fortemente connesso con l'Osservatorio Astrofisico di Arcetri al punto da avere, per regolamento, lo stesso direttore, ha dovuto affrontare un processo più complesso: diviene Dipartimento di Astronomia e Scienza dello Spazio solo nel gennaio 1989. Il Prof. Noci è stato anche il primo direttore del Dipartimento.

Reimar Lüst [4]

Ladies and Gentlemen, dear Beppo, first of all I would like to thank those who have organised this event: Prof. Blasi, Prof. Bonetti and Prof. Chiuderi, for inviting ESA and my colleagues from ESA, to attend this meeting.

There is some hesitation on my part to speak, because one might ask what ESA has to do with Arcetri, and with those who have worked in the 20s and the 30s. I think that there is a very good reason, since space research, and in particular the European Space Research activities, were founded and are going back to the work of those physicists who have worked in high energy Physics and particularly in cosmic rays: they were the driving force for starting European space scientific activities [5].

If I went back in history and if I asked when this started in Europe, it might be appropriate to mention two names: first, 1912 when Hess made his first balloon flight and found that there is a radiation penetrating in the atmosphere [6] and finally it was confirmed that those rays are coming

[4] Per i profili biografici del Prof. Reimar Lüst e dei successivi relatori si rimanda alla fine del volume.

[5] Già prima degli anni '60, in seguito alla scossa provocata dal lancio del sovietico Sputnik, in Italia si era costituito, per iniziativa di Edoardo Amaldi e dell'ingegnere e generale dell'Aeronautica Luigi Broglio, un Comitato per le Ricerche Spaziali (CRS), nell'ambito del Consiglio Nazionale delle Ricerche. Hanno fatto parte del CRS, tra gli altri, Nello Carrara per l'Università di Firenze e Guglielmo Righini per l'Osservatorio Astrofisico di Arcetri. Questo comitato rappresentò l'Italia nelle trattative che nel 1962 portarono alla firma per la costituzione dell'European Space Research Organisation (ESRO), che però non divenne realtà concreta fino al marzo 1964. Dopo circa un decennio, all'ESRO subentra l'ESA; vedi nota 22 (se non specificato diversamente i richiami alle note si riferiscono alla parte in cui sono inserite). Una trattazione critica delle origini dell'attività scientifica spaziale in Italia si trova in [9]. Nello Carrara (1900-1993), coetaneo e compagno di studi di Fermi e Rasetti a Pisa, si dedicò alle radiocomunicazioni e alle applicazioni delle onde elettromagnetiche. Insegnante per molti anni all'Accademia Navale e poi all'Università di Firenze, creò il Centro Studi per la Fisica delle Microonde (poi IROE, Istituto Ricerca Onde Elettromagnetiche, ora IAC, Istituto di Fisica Applicata "Nello Carrara" del CNR) e la società SMA (Segnalamento Marittimo ed Aereo). Guglielmo Righini (1908-1978), laureato in Fisica a Firenze nel 1930, nel 1933 vince la posizione di Aiuto negli Osservatori Astronomici. Ha trascorso periodi di lavoro ad Utrecht (NL), a Sacramento Peak (USA) e a Cambridge (GB) occupandosi di spettroscopia, fisica solare, radioastronomia. Insegna a Padova ed ha la direzione dell'Osservatorio di Asiago. Vinta la cattedra di Astronomia dell'Università di Firenze, dal 1953 è il successore di Giorgio Abetti alla direzione dell'Osservatorio Astrofisico di Arcetri, incarico che conserva fino alla morte. Luigi Broglio (1911-2001), professore e preside della Scuola di Ingegneria Aerospaziale dell'Università di Roma. In collaborazione con la NASA, realizzò il progetto San Marco per il lancio di satelliti in orbita equatoriale.

[6] Si riferisce al volo effettuato nell'agosto 1912 in Austria dal fisico Victor Franz Hess (1883-1964), che portò in quota tre elettroscopi del tipo allora usato per misure di radioattività. I risultati su questa "radiazione dall'alto di grande potere penetrante" apparvero pochi mesi dopo in *Physikalische Zeitschrift*. Hess vinse il premio Nobel per la Fisica nel 1936, condividendolo con Carl David Anderson; vedi parte II, nota 43.

from the outside. Second, I would like to mention Bruno Rossi, the so famous "Rossi curve" [7] and his further work in cosmic radiation. These are two names which are coming to my mind, but also I would like to pay a tribute to all those who have worked here in Italy and helped us in Europe, for coming together, and, at least for me personally, Varenna has played a very important role in this. The Varenna summer schools, but also the comic ray meeting which was held in Varenna in 1957: this was one of the cosmic ray meetings which took place every second year. My very first cosmic ray meeting, which I could attend as a very young physicist, took place in Bandera de Vigo. At that time, at the centre of discussion were the mesons and, if my memory is correct, particularly the question of π mesons had been discussed very heavily. But in Bandera de Vigo for the first time there was also a small group, which had, so to speak, an extra meeting, discussing cosmic ray variations and other effects: for the first time connections between cosmic rays and astrophysics had been discussed; then at Varenna in '57 the whole of astrophysics was an essential part of cosmic rays. But I should also recall the COSPAR [8] meetings, which were held here in Firenze: Hendrik van de Hulst, who will speak later, reminded me yesterday that there were two COSPAR meetings. I attended the one in '65 [9]: Beppo was here with a very heavy motorcycle, if I remember it correctly, and I was somewhat scared to sit on it when he was driving me out, to the place which at that time was offered by Firenze to put ESRIN [10]: it must not have been very far from here, near the "autostrada".

[7] B. Rossi, "La curva di assorbimento della radiazione corpuscolare penetrante", *La Ricerca Scientifica*, III (1932) 435.

[8] COSPAR: Committee on Space Research, fu costituito dall'International Council of Scientific Unions nel 1958, durante l'Anno Internazionale di Geofisica (Moscow, 1957-1958). L'iniziale, e generica, finalità del Comitato era di favorire l'attività pacifica nello spazio "condotta con razzi o con veicoli portati da razzi", senza tuttavia farsi coinvolgere nei relativi aspetti tecnici. In effetti, esso ebbe poi lo scopo di coordinare e promuovere lo sviluppo della ricerca spaziale tra i paesi membri, solo in parte europei. Il primo presidente del suo Executive Committee fu H.C. van de Hulst.

[9] In realtà la 7ª Assemblea Generale COSPAR si tenne a Firenze nel maggio 1964. Il meeting precedente nella stessa città era stato nell'aprile 1961 e va ricordato che fu in quell'occasione che Luigi Broglio propose nell'ambito del progetto San Marco, la realizzazione di un satellite scientifico tutto italiano destinato alla misura dell'atmospheric drag, dietro richiesta dell'Air Force statunitense. Invece, nel maggio 1965, l'8ª Assemblea Generale si svolse a Buenos Aires.

[10] ESRIN: European Space Research Institute. Questa sigla indica il Laboratorio Europeo per lo studio teorico e sperimentale di vari aspetti dell'esplorazione spaziale: l'interesse sarà principalmente per la Fisica dei Plasmi. La costituzione dell'ESRIN (inizialmente ESLAR: European Space Laboratory for Advanced Research) fu uno dei risultati dell'organismo preliminare COPERS (vedi poco più avanti) che lavorò per la nascita dell'ESRO: oltre all'ESRIN, le altri sedi della struttura erano la sede centrale di Parigi, ESTEC in Noordwijk (NL), ESOC a Darmstadt (D) ed Esrange a Kiruna (S).

I should certainly also mention then the initiative, which had been taken by Prof. Amaldi, for starting bringing together the physicists in Europe for the discussion of a plan of an European Space Research Organisation. This took place at the first COSPAR meeting in Nice and Hendrik van de Hulst was at that time the first president of COSPAR. Those, who were coming together at that time were Prof. Amaldi, Henk van de Hulst, Prof. Auger[11] also a cosmic ray physicist, and Sir Harry Massey[12]. The idea was to form something very similar to CERN, since CERN was functioning very well and was in the mind of those who felt, if one could embark Europe in space, then this could only be done together. This initiative which had been taken in Nice, and by the way there was also an article written by Prof. Amaldi on this subject outlining the first idea of a European Space Research Organization, this initiative ended up that the governments finally could be convinced to call a very first meeting on the ground of CERN in Meyrin[13], and there was a very first agreement

L'ESRIN, come struttura da realizzarsi sul territorio italiano, fu fortemente voluta da Luigi Broglio, ma altrettanto fortemente avversata da altri paesi (principalmente UK) in quanto ritenuta troppo lontana da ESTEC (European Space Research and Technology Centre). L'idea fu finalmente accettata nel giugno 1962; l'Italia propose una sede vicino ad Arcetri, per la sua tradizione nella ricerca astronomica, o, alternativamente, Frascati. Da parte italiana, la scelta di Firenze aveva ricevuto anche l'appoggio politico ministeriale, ma nel 1965 il neo presidente dell'ESRIN, H.L. Jordan, decise per Frascati, a causa della prossimità con laboratori affini, come l'elettrosincrotone e l'anello di accumulazione o il centro di ricerche aeronautiche dello stesso Broglio. ESRIN iniziò la sua attività scientifica nel 1966 ma la terminò nel 1973, dopo che tale attività fu giudicata di alto livello, ma non connessa con i programmi dell'ESRO. Scartate le ipotesi di nazionalizzazione o di cessione a terzi, l'Italia fece il possibile per evitare che ESRIN fosse estromesso dall'ESRO, com'era invece intenzione di quest'ultima. Alla fine si trovò un accordo affinché divenisse sede del Servizio Documentazione dell'Agenzia (1981). Dal 2004, oltre ad essere "European Centre for Space Records" è la sede ESA per le attività di osservazione della Terra. Da notare che questo ruolo era già stato proposto da Gianni Puppi (vedi parte II, nota 53), già membro del CRS (vedi nota 5) e presidente del Consiglio dell'ESRO al tempo della crisi dell'Istituto: "ESRIN…un laboratorio per studiare le risorse della Terra ed i fenomeni meteorologici".

[11] Pierre Auger (1899-1993), professore di Fisica a Parigi dal 1936, ha lasciato il suo nome all'effetto relativo all'autoassorbimento atomico dei raggi X. Promosse la costituzione della Commissione Francese per l'Energia Atomica, CEA, del Comitato Nazionale Francese per gli Studi Spaziali, CNES, e con Edoardo Amaldi, del Centro Europeo per le Ricerche Nucleari, CERN. Auger ed Amaldi sono riconosciuti anche come i primi, instancabili proponenti della collaborazione scientifica spaziale su scala europea.

[12] H.S.W. Massey (1908-1983), professore di Matematica e Fisica all'University College di Londra, attivo nel campo della Fisica Atomica e della Geofisica ed uno dei fondatori della ricerca spaziale, era il delegato britannico nel COSPAR.

[13] Comune nei dintorni di Ginevra, dal 1954 sede del CERN. L'incontro si svolse a fine novembre 1960 e creò un primo organismo di valutazione di fattibilità chiamato COPERS e finalizzato alla costituzione di una struttura spaziale europea (vedi nota 5).

for a preliminary organisation called COPERS[14]: I couldn't even bring together for what this stands, may be Henk van de Hulst can remind me... [*intervento di van de Hulst dal pubblico che suggerisce qualcosa ma non è percepibile*] ...and in this way the first steps of the European Space Research Organisation were taken. Certainly in this connection I should also mention that it was Henk van de Hulst, who at one of the council meetings mentioned my name and brought me into play.

At that time I had been asked to work as a so-called co-ordinating secretary of the scientific programme and tried to help to prepare the first scientific programme. This was started in 1961 and we looked around Europe to see where there were groups interested, and again they were mainly the first groups who worked, in one way or another, in the cosmic ray physics, who proposed the very first experiments and, to a minor extent, the astronomers. But if my recollection is right, one had to convince more the astronomers that there was some potential in space observation. At that time the astronomers were afraid that one would spend too much financial means in space and these financial means would be taken away from ground-based astronomy. Now, I believe, the astronomical community is convinced that space observations are a necessary supplement to the ground observations, in the optical range as well as in the radio wave range.

Then I started the preparation and I drew up a plan. Looking backwards, it was quite fantastic what we all hoped to do with so little money: this was put together in a so-called "Blue Book"[15].

But I should also mention that after half the first year I had the chance to accept an invitation by MIT and at that time I learned from Bruno Rossi and his co-workers about the first measurements of the solar wind whereas, before, it only had been proposed by the theoreticians[16]: the very first measurements were made with the "plasma cup"[17]. At that time

[14] La sigla COPERS è l'acronimo del francese "Commission Préparatoire Européenne de Recherche Spatiale".

[15] Uno dei primi rapporti sul programma scientifico, che prese nome dal colore della sua copertina. La prima edizione apparve già nell'ottobre 1961, a cura di uno dei due gruppi di lavoro del COPERS, il Scientific and Technical Working Group (STWG), che doveva valutare le implicazioni tecniche e finanziarie delle proposte di attività spaziale. Dal Blue Book doveva dipendere tutto il successivo sviluppo ed organizzazione della collaborazione. Il rapporto prevedeva oltre 400 lanci in 8 anni.

[16] Il riferimento è ai lavori di Sydney Chapman (1888-1970), un professore di Manchester esperto in Geomagnetismo ed in Fisica dell'atmosfera, che già negli anni '50 aveva condotto studi sugli effetti terrestri dei massimi di attività solare ed aveva proposto un primo modello di vento solare.

[17] Si tratta di una coppa di Faraday con una griglia modulata per raccolta di ioni con differenti energie nello spazio interplanetario. Si veda: H. Bridge, C. Dilworth, B. Rossi, F. Sherb, E. Lyon, "An instrument for the investigation of interplanetary plasma", *Jour. Geophysical Research*, 65, n. 10, October 1960.

at MIT there was also the start of the x-ray astronomy by Bruno Rossi and his colleagues.

Let us now come back to how we brought up the European Space Research Organisation. I think that the essential point at that time was that the scientific planning had been done by those groups who were actively involved and certain working groups were created, we called them "ad hoc working groups", "ad hoc" always meant a very long lifetime [18]. There was one particular group, this was the COS group, who played a special role in the planning of the scientific programme. Indeed some in this group, I think practically all of them, were coming from or had their background in, cosmic ray physics, but they were interested in astrophysics, more and more. This group had their meetings not so often as it should have in Paris, but the group met in very strange places all over Europe, quite often just at different airports. The chairman of this COS group was Beppo Occhialini and, if my memory is correct, there was also a secretary for this group and I think he was Livio Scarsi [19]. And this group planned the very first gamma-ray experiment, a very simple spark chamber on TD-1 satellite, but then I think this was really the essential part of the European Space Research Organisation, the planning of a satellite entirely devoted to gamma-ray astronomy.

What was also new in the planning was that this satellite should have had only one single instrument, not many experiments like all the satellites before. But, nevertheless, this one single instrument was to be developed not by the agency, not by ESRO, but by different participating groups: this was the beginning of the so-called "Caravane cooperation" [20]. It was not easy at that time to convince the scientific community as a whole, involved in ESRO, that this would be the right way to do it, instead of

[18] Inizialmente i gruppi "ad hoc" furono otto. Occhialini era responsabile del gruppo "Cosmic Rays and Trapped Radiation" (COS).

[19] Livio Scarsi (1927-2006) studente e collaboratore per anni di Occhialini, fondò e diresse l'Istituto di Astrofisica Spaziale e Fisica Cosmica del CNR a Palermo. Esperto di Radiazione Cosmica, Astronomia X e dei Raggi Gamma, il suo nome è legato a numerosi esperimenti spaziali [9] come COS-B ed il satellite Beppo-SAX, lanciato nel 1996, per il quale nel 1998 vinse il premio "Bruno Rossi" dell'American Astronomical Society.

[20] Nel 1968, gli scienziati dei vari laboratori coinvolti nella progettazione degli strumenti e nell'analisi dati del progetto COS-B formarono la Caravane Collaboration. Quasi tutti i capigruppo erano presenti a questo convegno del 4 dicembre 1987. Essi erano stati G. Occhialini (Istituto di Fisica dell'Università di Milano), L. Scarsi (Istituto di Fisica dell'Università di Palermo), R. Lüst (Max Planck Institut für Extra-terrestrische Physik, Garching, D), E.A. Trendelenburg (Space Science Department, ESTEC, Noordwijk, NL), H. van de Hulst (Huygens Laboratory, University of Leiden, NL) e J. Labeyrie (Centre d'Etudes Nucléaires, Saclay, F). Alla collaborazione si aggiunse poi G. Hutchinson (University of Southampton, UK). Il termine "Caravane" fu suggerito da Giuseppe Occhialini stesso, in relazione all'abitudine di incontrarsi negli aeroporti, come carovanieri nei caravanserragli!

launching a satellite with many different experiments. It was the director of planning at that time, professor Dinkespiler, who had the courage to start the project.

First, the project was called COS-A but it turned out, as in almost every planning, that COS-A was too big and too expensive and then one had to say "B" and this was then the satellite finally developed: COS-B [21]. For me, this was one of the most exciting project which ESRO had undertaken; there was the group in Leiden then there was the group in Saclay, there was the group in Milano and finally also in Palermo, there was the group in Garching and that in Noordwijk, from ESRO itself. All of these contributed to the experiment of COS-B. The remarkable thing was that the experiment really worked, in spite of the fact of so many contributions: the satellite worked much longer than had been foreseen, but this created budgetary difficulties since one had to provide the budget for years of operations which were not planned for.

When I now try to compare the situation of ESA [22] today with that of the days of ESRO and particularly of the planning of COS-B – then one has to realise that at that time ESRO was an organisation entirely devoted to scientific research, while at the beginning of the 70's the governments were becoming more and more interested in application, and so finally ESRO was transferred to an agency where science only takes about 10% of the whole activity. But nevertheless I feel for the present organisation that the scientific programme is, and must be, the backbone of the whole European Space Agency. You might ask why is this so important; the first point is that it has been proven that all scientific projects are projects which normally promote the next step in technology, pushing technology, and in each scientific project one must also be willing to accept certain risks, while in applied projects, this is normally not accepted.

But the second point, I feel is even more important for ESA and also for the whole development of space activities, and that is the way scientists are co-operating in Europe; in our case, I think, when we started, there were never real difficulties in co-operating across borders, as CERN had demonstrated. And this still is what we need, this very open

[21] COS-A doveva effettuare osservazioni sia nei raggi X che nei raggi gamma, mentre COS-B coprì solo il dominio gamma. Fu operativo dall'agosto 1975 all'aprile 1982. L'astronomia X fu riproposta da Constance "Connie" Dilworth (1924-2004) dell'Università di Milano e da J.A.M. Bleeker dell'Università di Leida, col progetto HELOS, Highly Eccentric Lunar Occultation Satellite. Dilworth fu responsabile del gruppo COS nel biennio 1967-1968, mentre Occhialini, suo collega e marito, lo era stato nel biennio 1964-1965.

[22] La creazione di ESA, ossia di un'unica Agenzia europea che assorbisse le organizzazioni spaziali preesistenti, come appunto ESRO, fu concordata, sotto la guida di Giampietro Puppi (vedi parte II, nota 53), nel luglio 1973 e divenne effettiva nell'aprile 1975. L'Agenzia Spaziale Italiana, ASI, risale invece al 1988, l'anno seguente al presente Convegno.

co-operation and competition among scientific groups. Otherwise we could not co-operate in Europe, since Europe is still a rather difficult entity: it still consists of national States, which have their own interests and their own ideas. I think science and the scientific community play an important part in keeping ESA as a co-operative effort together. And this one could also sense when we had our last ministerial meeting just three weeks ago in den Haag, where the ministers decided and agreed on a long term plan for the European Space activities.

The difference between the scientific programme and the other programmes in the Agency is that in a scientific programme all member States must participate, while in all other programmes, as optional programmes, member States can participate according to their interest and financial means. But the remarkable part in the science programme, this mandatory programme, is that we never had problems with the so-called "return factor" [23] as far as scientific experiments are concerned. Always, as it has been established, and there again, I think, the COS-B group played a very important role; there was scientific merit and scientific excellence that were decisive in the selection and the acceptance of a scientific experiment. I want to stress that it is important that the scientific community support this, and does not want to have any kind of geographical distribution according to the financial contribution of each member State.

I would like to close this summary of how ESRO was built up, just showing a number of viewgraphs, where one can see the number of satellites, which have been launched so far, and one will see that all this goes back to the time… [*si interrompe per disporre sul proiettore un lucido dal titolo "Scientific Spacecraft Launches" che mostra una tabella di 14 missioni con nome, finalità e data di lancio*] [24].

It is practically twenty years ago, namely 1967, the first ESRO satellite "ESRO 2" was launched; unfortunately, the very first one is not shown here: it was launched only in a geostationary orbit just some hundred meters below sea-level (!) since the Scout rocket did not work [25]. Therefore

[23] Con questo termine ("Principle of just return") ci si riferisce alla proporzionalità tra percentuale dei contributi nazionali al bilancio dell'Agenzia europea, e vantaggi "di ritorno" nella distribuzione delle commesse industriali.

[24] Un elenco dettagliato delle missioni qui citate, insieme ad altre, si può trovare sul sito dell'ESA, cercando al suo interno "ESA - ESOC mission history". Alla data presente l'indirizzo della pagina web è la seguente: http://www.esa.int/SPECIALS/ESOC/SEMEFCW4QWD_0.html. Per una cronologia ragionata dei lanci si veda anche: http://www.astronautix.com/craft/esro.htm

[25] Quest'affermazione e la seguente non sono molto chiare e neppure del tutto corrette: a causa di problemi tecnici con l'altro piccolo satellite, ESRO II fu lanciato per primo, nel maggio 1967. Ma il terzo stadio dello Scout esplose ed il quarto non si accese, quindi il satellite fu fatto cadere nell'oceano. Oltretutto, il fallimento di questo lancio avvenne in un momento molto critico per l'organizzazione sotto la direzione di

ESRO 2 was already the second flight module which was finally launched. You can see here that satellite activities started with cosmic rays and also with some solar physics.

I should also mention HEOS A[26]: this was the first interplanetary mission, and also the COS-B group was heavily involved in its planning. Beppo was always saying there was a bomb on board, this was the barium cloud experiment[27] at that time; then I should also mention the TD-1[28] satellite, with the first spark chamber and then the COS-B, which, as I mentioned, was the first observatory-type satellite of ESRO. Since the lifetime of COS-B was 7 or 8 years... [*van de Hulst corregge:* "Six, six and half"] Then there was EXOSAT[29] which was also planned and heavily discussed by the COS group for cosmic x-rays. From the original planning until its becoming operative, it changed considerably, and EXOSAT finished its life, I believe, in '86[30], so, again, much longer than had been foreseen. Then we find Giotto[31], the fly-by mission to

Auger. Subentrò allora il britannico Hermann Bondi. I lanci furono riprogrammati per l'anno successivo: ESRO II (raggi cosmici e fisica solare, ribattezzato *Iris*) a maggio, ESRO I (ionosfera polare, ribattezzato *Aurorae*) in ottobre e HEOS 1 nel dicembre 1968. Furono un successo: la crisi era superata. Hermann Bondi (1919-2005), fisico ed astrofisico austriaco naturalizzato britannico, dal 1954 professore al King's College di Londra, fu autore con Thomas Gold e Fred Hoyle di un modello cosmologico stazionario. Rimase Direttore Generale dell'ESRO fino al 1971, per poi divenire Consigliere Scientifico del Governo britannico.

[26] HEOS: Highly Eccentric Orbit Satellite; infatti aveva un apogeo di 240 mila km, contro i 1000-1500 km degli ESRO. In seguito il suo nome fu cambiato in HEOS 1. Venne lanciato da Cape Kennedy, attraverso un accordo con la NASA, per studiare, oltre ai raggi cosmici, la fisica del plasma ed i campi magnetici nello spazio interplanetario. A partire da questo satellite, il razzo vettore Scout venne sostituito con gli americani Thor Delta, più potenti e con circa la metà del costo per chilo di payload.

[27] In questo esperimento veniva rilasciata una nube di Bario nella Ionosfera per studiare l'effetto del vento solare.

[28] La sigla TD indica appunto il vettore Thor Delta, che permetteva di posizionare satelliti su orbite che uscivano dalla magnetosfera. I campi di ricerca specifici furono l'astronomia stellare (TD-1), l'astronomia solare (TD-2), gli studi sulla Ionosfera (TD-3) e sull'atmosfera terrestre (TD-4).

[29] EXOSAT: European X ray Observatory Satellite. Questo satellite si riconduceva a quello inizialmente proposto da C. Dilworth e J. Bleeker (vedi nota 21). Il lancio avvenne solo nel maggio 1983, con 6 anni di ritardo anche per motivi di bilancio e dopo una lunga, complessa discussione sul vettore da usare.

[30] EXOSAT compì 1780 osservazioni tra maggio 1983 e aprile 1986.

[31] La sonda cometaria Giotto è stata la prima missione ESA nello "spazio profondo". Ebbe nome dal famoso affresco del pittore nella Cappella degli Scrovegni (Padova) in cui la cometa Halley è rappresentata nel suo passaggio del 1301. La sonda, lanciata nel luglio 1985 con razzo francese di tipo Ariane, nel marzo 1986 si avvicinò fino a 600 km dal nucleo della cometa. Poiché molti strumenti sopravvissero a questo storico incontro ravvicinato, sei anni dopo, nel luglio 1992, fu utilizzata di nuovo per osservare un'altra cometa, la Grigg-Skjellerup.

Halley's comet. This fly-by mission was a dream already from the very beginning of ESRO's days [32].

At that time, we had two large projects in mind: a large astronomical satellite, and what was called "the second large project", which was discussed for quite some time as a cometary mission and I would like to show at least the famous picture, which had been taken by the camera of Giotto [*mette sulla lavagna luminosa la nota fotografia del nucleo di Halley* [33]]. It is hard to see, but there you can see just some parts of the cometary nucleus; at least, I think, you can see here some structures: the nucleus had an extension of about 15 km in one direction and 8 km in the other direction, and a potato-like shape...

[*Dopo una interruzione la videoregistrazione riparte con una tabella che mostra le caratteristiche di altre missioni*] You can also see from this picture how the satellites developed their capacity. ESRO 2 had a weight of 75 kg, a power of 40 watt and a bit-rate slightly over 100 bits per second. The newly planned Giotto already had a weight of almost 1 ton and a considerable bit-rate of almost 50,000 bits per second.

The next astronomical satellite, which is under development, is Hipparcos [34], already over 1 ton and then the next astronomical satellite, ISO [35], the infrared satellite, will come to a weight of nearly 2 tons: this development, as one can clearly see, and also the bit-rate, are very remarkable for scientific data.

I would like to mention also [*inserisce un nuovo lucido di dati, che legge*] that when it started in '61, there were 10-15 scientific groups all over Europe which carried out experiments with sounding rockets and satellites and all together, at that time, we had a statistic that about 300 scientists were more or less involved in this. Today, there are at least 40-

[32] La realizzazione della missione Giotto assorbì più risorse del previsto, ritardò il lancio del costoso Hipparcos ("Le stelle possono aspettare, la cometa no" si disse) e creò una spaccatura all'interno dell'Organizzazione Spaziale Europea, soprattutto tra le parti tedesca e francese, essendo quest'ultima più favorevole al satellite astrometrico.

[33] Si tratta della prima foto in assoluto di un nucleo cometario. La sonda Giotto detiene anche un altro record: il passaggio più vicino ad una cometa, la già ricordata Grigg-Skjellerup, a soli 200 km.

[34] Satellite per astrometria che prese il nome dall'astronomo greco che nel II secolo a.C. compilò il primo catalogo stellare. Destinato ad eseguire accurate misure di coordinate stellari e di moti propri, anche ai fini dello studio della dinamica galattica, fu lanciato nell'agosto 1989 e rimase operativo per quattro anni, determinando la posizione di 120 mila stelle. Insieme alla missione Giotto, costituì il più acclamato prodotto della ricerca spaziale europea negli anni '80. L'esito positivo del lancio di Hipparcos e di Giotto, ambedue con razzi Ariane e quindi missioni tutte europee, originò un netto ridimensionamento della collaborazione con la NASA, dove invece si erano avuti diversi problemi con i lanciatori.

[35] Per questa missione si veda la nota 42.

50 scientific groups in Europe, who are developing hardware for scientific satellites and our estimate is that about 100 groups are involved in making use of the observations by ESA satellites and, all together, about 2000 scientists are actively involved in the scientific data.

But I should also show what are the financial means, compared with those of the Unites States. Here is... [*ulteriore lucido con istogrammi; i dati mostrati sono esattamente quelli letti e qui riportati*]. There has been discussion in Europe, especially concerning our current planning, that we might spend too much on space activities, and as you can see here the NASA budget, which is a civilian space budget, in '86 was 7.5 billion dollars; in ESA we had just roughly 1 billion dollars, and NASDA[36], the Japanese agency, somewhat less. The other column is still the military space budget in the United States, again as expenditure pro capita: we can see that in the United States one is spending 31 dollars pro capita, in Japan a little more than in Europe, i.e. 6.4 dollars and we in Europe roughly about 6 dollars per year pro capita.

This is the situation about the launch of satellites itself. I took here [*mostra un nuovo lucido*] the year '85, before the Challenger accident[37]: the United States launched 17 satellites, we here in Europe 3, Japan 2, China 1 and the USSR 98. But one should see that three quarters of these Russian satellites were military satellites, mainly with a rather short lifetime. If we are looking back [*mostra un nuovo lucido con i lanci 1957-1986*] since the first launch, the Sputnik[38], altogether almost 3000 satellites have been launched, almost 2000 from the USSR, the USA 745 and Europe 40, but then of course the United Kingdom and France had some of their own programmes.

As the final picture [*mostra un lucido dal titolo "What's up in Space"*], I should show the number of satellites still in operation: 342, and again only very few of these satellites are scientific satellites, most of them are for application purposes. ESA itself has at the moment two spacecrafts in orbit and in operation, and a number under development.

Let me conclude in this way: for me one of the most rewarding things working in space was the very personal friendship I gained with so many people, and among them Beppo was for me very special [*si volge verso*

[36] NASDA: National Space Development Agency. Dall'ottobre 2003 l'Agenzia si è unita ad altre organizzazioni giapponesi di ricerca spaziale per formare la JAXA, Japan Aerospace Exploration Agency.

[37] L'esplosione del Challenger, attribuita ad una guarnizione difettosa del serbatoio, avvenne il 28 gennaio 1986 durante il decollo e causò la morte di 7 astronauti.

[38] Il primo, storico, satellite artificiale ufficiale (Sputnik: satellite). Fu lanciato dal cosmodromo, ancora oggi utilizzato, di Baikonur (URSS - adesso Kazakhstan) il 4 ottobre 1957, in occasione dell'Anno Internazionale di Geofisica e rimase operativo per 21 giorni. Bruciò per attrito con l'atmosfera durante il rientro alcuni mesi dopo.

Occhialini], for the way you were willing to help me in the 60's and the way you demonstrated how one could work together. I would like to thank you, Beppo, for your help and for the friendship you have given to me, and many others, in working in space as we have built up ESRO.

Giancarlo Noci

Thank you Prof. Lüst for this panorama of the early days of space activity and for the survey of the more recent status.

Roger Bonnet

It is certainly for me a great honour to be here today and to address myself to this distinguished audience, where most hair is white in colour, including mine.

It is a great pleasure to celebrate this day and to pay tribute to the pioneers of Europe who have paved the way to developing a beautiful and very excellent scientific activity. I think it is the tribute of these pioneers like Beppo Occhialini and also Jean-Claude Pecker[39] who at that time was working also in the astronomy domain, in ESRO, in the very early days of ESRO. They have found the way to select the best scientific missions after a fairly fierce competition in the domain of science. The best scientific missions always came at the end of a very, very sophisticated process, but, at the end, although our number of missions in Europe is not very large, I must say that scientific excellence has always prevailed as a criterion for selection and has indeed always proven to be the characteristic of these missions.

I will try to be very brief because time is short, but I want to show you how today we intend to continue this experience and this excellence, which was shown to us in the past and has been left to us now. This [*mostra un lucido con una composizione di disegni di cinque satelliti nello spazio tra la Terra ed il Sole*], against the background of the stars, is what we intend to do in the next ten years in terms of scientific explorations. As professor Lüst has indicated to you, space activities in ESA are mostly mandatory and they incorporate the study of the Universe, the Sun and the study of the relations between the Sun and the Earth.

[39] Nel marzo 1961, il Comitato COPERS (vedi note 13 e 14) aveva formato un gruppo di lavoro chiamato STWG (nota 15). Nell'aprile 1961, lo STWG si riunì a Stoccolma per valutare i progetti scientificamente e tecnologicamente sostenibili e per costituire una serie di sottogruppi tematici. Jean-Claude Pecker (1923) dell'Osservatorio di Meudon e professore al College de France, era responsabile del "Tracking and Data Handling" ed ebbe un ruolo molto attivo nel STWG. Fu anche responsabile di uno dei gruppi "ad hoc" (nota 18): il "Solar Astronomy and General Astronomy".

Here is a set of four satellites, or better four missions: one of which is the missions Ulysses [40], which will explore the outskirts of our solar system, but not in the plane of the ecliptic: above the plane of the ecliptic. This is to be launched in 1990 by the Space Shuttle. Hipparcos [41], which was mentioned by Reimar Lüst, is a very unique mission in Europe, in the sense that it will not observe the radiation of the stars, but it will measure the position of stars with a very great accuracy, and will provide a catalogue of the position and proper motion of stars, which will allow us to measure the cosmic scale of the Universe. This project, ISO [42], the Infrared Space Observatory, is one of the most ambitious satellites we have developed today and which is in the planning stage: it will explore the very cold Universe. And there is a set of missions, two missions which I will comment on, later.

Let me not forget that, since in ESA we are not at the same level of financing as the Soviets and the Americans, if we want to do even more ambitious programmes, we usually have to do them in cooperation. This is the case of the Hubble Space Telescope [*pone sul proiettore un lucido con un'immagine dell'HST*], which is an American satellite to be launched in 1989 [43] by the Space Shuttle, and which is, with respect to the normal ground-based standards, not very big: it is a 2.4-meter telescope. But this telescope has the ability to explore the very limit of the Universe just by the mere fact that it orbits the Earth, above its atmosphere, far away from

[40] Pronto già nel 1983 e programmato per il 1986, era stato rimandato a causa del disastro del Challenger all'inizio di quell'anno. Missione congiunta ESA-NASA, fu lanciato nell'ottobre 1990 dallo Shuttle Discovery, su un'orbita come qui descritta (infatti il nome originale della missione era OOE: Out-Of-Ecliptic) per lo studio dei poli solari e per misure di vento solare. Ulysses faceva parte della fascia di missioni di medio-alto costo, come Giotto ed Hipparcos, attivi con successo al momento di questo successivo lancio.

[41] Vedi nota 34.

[42] Costoso progetto concorrenziale, a livello di bilancio, con varie altre missioni ed in particolare con una missione solare, fu finalmente lanciato nel novembre 1995, con due anni di ritardo per problemi anche al criostato, che doveva mantenere a 3 K il piano focale del telescopio. Il lancio di ISO testimonia il crescente interesse verso l'astronomia fuori dal visibile, e specialmente in questa banda (2 - 200 μm). Inoltre, come sottolineò Edoardo Amaldi, presidente del Comitato di Consulenza (SSAC), la novità di questa missione fu di essere caratterizzata da un telescopio ad alto costo ma sfruttabile da tutta la comunità astronomica. In questo differiva (a parte il caso del COS-B) dalle precedenti missioni a basso costo e con vari esperimenti, ma tutti d'interesse solo per un numero limitato di astronomi. Se da un lato la realizzazione di ISO penalizzò per anni altri progetti e quindi fu accolta con disappunto da molti scienziati, dall'altro lato questa missione si collocò ad un livello di qualità confrontabile con quello della NASA. Chiusa la missione nel maggio 1998, ISO ha effettuato quasi 30 mila osservazioni, dal sistema solare alle più lontane sorgenti extragalattiche.

[43] Inizialmente chiamato LST, Large Space Telescope, e programmato per il 1983, fu rimandato al 1986 per una serie di problemi tecnici. Infine fu lanciato nell'aprile 1990, poco prima di Ulysses (vedi nota 40) e con la sua stessa motivazione per il ritardo.

the light of the Earth and from its atmosphere. It is thus able to penetrate deep into the Universe and look at very faint objects there, that is to say, at objects which are far away. ESA is participating in this programme with a proportion of 15% [44]. This satellite weighs around 14 metric tons, so we are far from the few hundred kilograms of the first satellites. This reveals the general trend of space activities: the slide provided to you, shown by Prof. Lüst, was a very good example of how the capabilities of satellites are evolving.

Today, if you really want to explore new domains, your instrumentation has to be sophisticated and, therefore, probably bigger and, at the same time, more expensive. This is why, when in the early 80's we looked at the future of what the activities of Europe could be, it was striking that, if we wanted to remain competitive in the domain of science, we could not do it with the same financial means which had been set up in the early 70's, in '71 exactly. At that time, the scientific budget of ESRO was defined as being 27 million accounting units. This, updated to real purchasing value at the end of the 80's, was around 100 million accounting units. As compared to what the Americans are spending in space, there is a factor of 10 in scientific research and that, of course, means that basically you can't develop satellites which are at the same level; or you develop one satellite when the Americans develop ten satellites. And therefore you are limited in your scope.

Well, these problems have several solutions: one of them, obviously, has been to try to increase a little bit the scientific budget while, at the same time, limiting ambitions: this was the general framework of the preparation of the so-called Space Science Horizon 2000 plan [45], which we developed according to the rules which ESRO had set up in the very early years of its existence. This is to say, asking the scientific community to provide us, to provide ESA, with the best ideas and by this process we are always sure that we select missions that the scientists lack, because the missions are proposed by them. We do not invent these missions in the bureaucracy of ESA: they come from the active part of the scientific community and they are introduced into the system by them, through their analysis and their peer review committees. This is how we managed.

In 1983, we asked the scientific community to provide us with ideas for missions and we received more than eighty such ideas, which were

44 Il principale contributo ESA fu in effetti la Faint Object Camera (FOC).

45 All'inizio degli anni '80, ESA decise di definire la programmazione a lungo termine. Rappresentanti della ricerca spaziale europea si riunirono nell'isola di S. Giorgio a Venezia, tra fine maggio e inizio giugno 1984, per stabilire le precedenze nell'attività futura dell'Agenzia: il risultato fu il piano "Horizon 2000", destinato a coprire il ventennio 1985-2004. Si individuarono anche quattro indirizzi fondamentali, detti "pietre angolari" (*cornerstones*), della ricerca: relazioni Terra-Sole; asteroidi e comete; survey nei raggi X; survey nel lontano IR e sub-millimetrico, come illustra qui Bonnet.

analysed by a committee chaired by Johann Bleeker[46] from the Netherlands, a young Dutch scientist who was at that time the chairman of the Space Science Advisory Committee (SSAC). This committee has paved the way to establishing the so-called Horizon 2000 programme, which is very limited in scope but ambitious in its scientific objectives.

Since we are celebrating the encounter between two worlds: "The infinitely great and the infinitely small", I will concentrate on a few examples of what the main elements of this plane are able to do in this domain. Let me start and I will concentrate first on the most important elements of this "Horizon 2000" plan.

[*Pone sulla lavagna luminosa un lucido con una coppia di satelliti tra Terra e Sole*] Let me consider the first cornerstone of this long-term plan, which has four cornerstones: this is a so-called Solar-Terrestrial Physics[47] cornerstone. This is made up of two satellites which were shown at a smaller scale on the previous slide. Actually, this one [*indica il satellite più vicino alla Terra*] which consists of a set of four satellites, will be in orbit in the magnetosphere of the Earth, measuring the plasma physics in the magnetosphere[48].

At the same time, another satellite will look at the Sun and measure its radiation, and especially the parameters of the solar wind as affected by the variations of our star. These two types of satellite measure the interaction between the Sun and the Earth. This is nice, but let me concentrate on another aspect of this mission, particularly on the one which is covered by the SOHO, Solar and Heliospheric Observatory mission[49] [*indica il satellite più vicino al Sole*].

[46] J. Bleeker (Università di Leiden, ed in seguito di Utrecht) aveva già collaborato alle missioni COS-B e HELOS (vedi note 21 e 29).

[47] Si tratta, in realtà, di una missione doppia, come risulta evidente, normalmente indicata nei documenti come STP o anche STSP, Solar-Terrestrial Science Programme.

[48] Il progetto Cluster, com'è stato poi denominato, è un sistema di 4 piccoli satelliti che orbitano in formazione attorno alla Terra. Sono finalizzati allo studio tridimensionale delle strutture a piccola scala del plasma e alle loro variazioni per effetto del vento solare. Difficoltà tecniche ed alti costi di realizzazione fecero anche valutare sia il ridurre a 3 il numero dei satelliti, perdendo però così l'osservazione tridimensionale, sia la possibilità di lanci separati. Nel lancio, verso metà del 1996, il primo set di satelliti fu perso nell'esplosione del vettore Ariane, a causa di problemi di sovraccarico che innescarono l'autodistruzione. Una prima reazione fu di usare subito un satellite di riserva riducendo il progetto ad una missione, giustamente ribattezzata "Phoenix", basata su un singolo elemento. Ma poi, per non rinunciare al programma scientifico originale, il lancio dei 4 satelliti fu reinserito per metà del 2000 col nome "Cluster II". A quella data, luglio 2000, fu lanciata solo la prima coppia, seguita dalla seconda coppia due mesi più tardi. Il sistema fu configurato e reso operativo nel febbraio 2001 con previsione di vita fino al dicembre 2005, ma ne è stata decisa l'estensione per altri 4 anni. In effetti, il prolungamento quadriennale delle missioni di successo è quasi una consuetudine per ESA.

[49] Il progetto SOHO ebbe gli stessi problemi, tecnici e finanziari, comuni a Cluster ed in effetti SOHO/Cluster era considerata una missione gemella. Il lancio del satellite

This mission takes advantage of a special position between the Earth and the Sun, where it can maintain a very steady velocity with respect to the Sun[50]. From this position you can measure the oscillation of the Sun: these very tiny oscillations are measurable not only in kilometres per second, not only in centimetres per second, but in millimetres per second. The Sun is slowly pulsating with an amplitude of a few millimetres per second: in order to detect these very tiny oscillations, you have to stay observing the Sun for a very long time, because the noise itself is very large, a few tens of centimetres per second.

What do you learn by doing that? You learn that the Sun is pervaded with periodic waves, and these periodic waves reflect, of course, the physical conditions inside the Sun, the temperature and the chemical composition: then if you select the correct waves, you can probe the interior of the Sun. For the first time, you can really go deep into the core of the Sun and even to its centre, where mystery exists in the physics of neutrinos. In fact, you know that the neutrinos from the Sun are a factor of three lower than what the theory predicts: this means that either the theory is wrong, or the model is wrong, or that the neutrinos have a mass and oscillate between free states, but we are able to measure only one state[51]. This is an assumption, a hypothesis which may be proven not only by this mission but also on the ground, by physical instruments and physical experiments. But if these physical instruments on the ground prove that this is true, then you have to check that the Sun is behaving according to these experiments and if you still measure something which is not compatible, then you have to improve your model and therefore you must completely change the domain of astrophysics. A domain where the smallest particles in physics, the neutrinos, can be incorporated in a

solare avvenne nel dicembre 1995, ed avrebbe dovuto essere seguito, dopo pochi mesi, da quello di Cluster (vedi nota precedente).

[50] SOHO è stato collocato in orbita stazionaria nel punto Lagrangiano L1, a circa 1.5 milioni di km dalla Terra. Questa collocazione consente di osservare il Sole ininterrottamente, a distanza quasi costante: questo è il requisito essenziale per rivelare le deboli oscillazioni all'interno della stella, mantenendosi fuori dalla magnetosfera terrestre per poter misurare il vento solare. SOHO riesce a misurare il Sole a strati, partendo dal nucleo fino allo strato più esterno. Il massimo del suo ciclo undecennale di attività si è verificato nel 2000, quindi la sonda ha ormai registrato un ciclo intero. Il funzionamento di SOHO, previsto fino al 2001, è stato esteso fino al dicembre 2009, in accordo con quello di Cluster ed anche per collaborare con altri satelliti solari in fase di sviluppo, di cui due dell'ESA.

[51] Questa ipotesi si è poi rivelata quella giusta, come è stato provato con esperimenti a terra nei primi anni 2000 e come era stato già ipotizzato dal fisico Bruno Pontecorvo nel 1962, e poi anche da altre teorie. Esistono 3 tipi di neutrini (e, mu, tau) e quelli emessi dal Sole, all'origine di tipo "e", si trasformano in una miscela che comprende anche gli altri due stati, sfuggendo così ai rivelatori. È attualmente questa, la soluzione del controverso ed importante problema dei "neutrini mancanti" del Sole.

volume as great as the Sun and where the infinitely small and the infinitely big get together.

Another interesting mission of this long term plan is the so-called X-ray Multimirror Mission[52] [*mostra l'immagine di un nuovo satellite*]. It is a great privilege to speak before so distinguished an audience, in the presence of some of the fathers of x-ray Physics, and in particular Prof. Rossi, of how we intend to solve some other crucial problems of cosmology. Of course, since cosmology and particle physics are now focussing on the same point, I think it's worthwhile to mention to you the objective of this mission, in this particular domain of particle physics and cosmology.

This is an x-ray telescope, whose objective is to gather, to grasp, the largest number of photons you can get above the Earth's atmosphere. The collecting area[53] of these telescopes is around 5000 cm^2 which may not seem too big, but for x-rays it's very big indeed, and what we intend to do with these photons is to analyse their spectral distribution. If you want to look at the very tiny and narrow lines in the x-ray domain, which tell us what the temperature and density of some plasmas are, then you have to get the highest sensitivity possible in order to resolve these lines and measure the flux.

This is one aim of this satellite, but another particular objective of the mission will be to observe the so-called dark matter in the Universe[54]. We all know that there is a factor of ten between the matter that we observe and the matter that we think is in the Universe. The matter may not radiate in the visible, or in other wavelengths where we are able to make

[52] XMM-Newton è un grande satellite (10 m in lunghezza, 16 metri di pannelli solari estendibili e quasi 4 tons) dotato di 3 telescopi, ciascuno contenente ben 58 specchi che lavorano ad incidenza radente alle energie dei raggi X (12 keV – 0.1 keV, ossia 0.1 – 12 nm). La prima proposta risale al 1982 ed il suo lancio è avvenuto nel dicembre 1999 con razzo di tipo Ariane. La durata della missione, inizialmente prevista di 2 anni, è stata estesa al marzo 2010. Il satellite ha un nome ufficiale ben più complesso: "High-Throughput X-ray Spectroscopy Mission", ma la più semplice denominazione d'uso "Multi Mirror" risulta giustificata dalla sua struttura. Il nome finale del satellite fu spiegato dallo stesso Roger Bonnet dopo il lancio: "Newton è l'uomo che ha inventato la spettroscopia e XMM è una missione di spettroscopia. Inoltre il nome di Newton è associato con la gravità e con XMM spero che si possa trovare un gran numero di Buchi Neri". XMM-Newton ha osservato la cometa periodica Tempel-1 durante l'impatto con un proiettile esplosivo, provocato dalla missione Deep Impact della NASA (luglio 2005), al fine di analizzarne i frammenti.

[53] In realtà essa dipende dall'angolo di incidenza che a sua volta è legato alla lunghezza d'onda da esaminare. La sezione degli strumenti è di 4300 cm^2 a 1.5 keV e di 1800 cm^2 a 8 keV.

[54] Il risultato di maggiore rilievo della missione è lo studio delle stelle di neutroni e dell'effetto del campo gravitazionale sulla radiazione. Per dare un'idea dello sviluppo delle capacità delle missioni, come già sottolineato in generale da Lüst, si consideri che il satellite XMM in un solo giorno misura in una certa zona del cielo più sorgenti X di quante non ne abbia rivelate su tutto il cielo il primo satellite X, Uhuru, lanciato nel 1970, durante i suoi tre anni di vita.

observations today, and it may well be that these wavelengths are in the x-ray domain, but with such a low flux that it cannot be detected with present-day instruments. This very high sensitivity spectroscopy mission will try to do that: if it succeeds, it may well detect the dark matter in the x-ray domain and measure the distribution of mass in the Universe, in galaxies and therefore help to solve this very crucial problem. Because if you can prove that indeed you have this matter and that galaxies possess mass that we cannot observe today, then you can come back to the assumption that there is enough matter to close the Universe, rather than having it expanding forever. This is a cosmological problem of great importance and, as you know, cosmology and particle physics are nowadays coming closer together.

Another interesting mission of this long term plan is this one [*mostra un lucido di un altro satellite*] which consists of going to a comet and extracting material form it. The idea is to land on the nucleus of a comet. Giotto[55] passed in front of Halley's comet at a velocity of 78 km/s, which is enormous and in fact Giotto lost in this encounter something like 600 grams of matter, just because of the smoke coming out of the comet: at this velocity, it is so energetic that it can break the spacecraft and remove matter from it. What we want to do on this mission[56] is the opposite, we want to have a very soft landing on the nucleus of a comet and extract some material from it. Why should we do that?

The reason is that comets are probably the remnants of the nebula which formed the solar system, and which is, in turn, a remnant of interstellar clouds which were ejected by stars at the end of their lifetime. These stars have undergone a very long process and their evolution may reflect the different conditions within our Galaxy. So, what we want to do here is to extract matter just as people at the poles of the Earth bore into the ice

[55] Si veda l'intervento di Lüst, nota 31 e seguenti.

[56] La missione non è più quella descritta nel seguito da Bonnet, ma è stata ridefinita, rinunciando a portare sulla Terra il materiale cometario estratto. Il nuovo progetto è stato approvato nel 1993 come pietra angolare di Horizon 2000. Il nome del satellite, "Rosetta", fa riferimento a Rashid, il luogo di ritrovamento (1799) nel delta del Nilo della famosa stele egizia incisa, che permise di decifrare i geroglifici e di comprendere l'antica civiltà egizia; similmente, la sonda permetterà di 'leggere' e comprendere le antiche pietre del sistema solare: le comete. Il lancio della sonda era stato programmato per gennaio 2003, per poi incontrare la cometa Wirtanen nel 2011 e studiarla fino al passaggio al perielio nel 2013. Alla fine "Rosetta" è stato lanciato nel marzo 2004 con razzo Ariane ed è composto di due parti: il satellite che resta in orbita ed il modulo che si posa sulla cometa. Dopo un viaggio di quasi 800 milioni di km, in un volo guidato anche dalla gravità della Terra e di Marte, all'inizio del 2014 "Rosetta" incontrerà la 67P/Churyumov-Gerasimenko, una cometa periodica (6 anni e mezzo) con un asse maggiore lungo 4 km. A quel punto il modulo verrà inviato sul suo nucleo e per due anni il satellite accompagnerà la cometa nel suo passaggio attorno al Sole. La fine della missione è prevista per il dicembre 2015.

to study the history of our climate. Here we will study the history of the "climate" of this corner of the Universe by extracting tiny grains of pristine material and looking at them in the laboratory. This is not an easy thing to do and one sequence of events which is possible is exemplified here on this graph [*una nuova trasparenza mostra schematicamente le previste fasi della missione*] where you see that a probe has to go to a comet, land on it, dig the hole, and it's better if it is done in several places and to several depths so that you are sure that several different samples have been taken for analysis later. Then the first probe has to reach a second one which is waiting here [*indica sul disegno*] and goes back to Earth for the analysis of the samples. This is such an ambitious mission that ESA alone cannot afford it and therefore we will study it jointly with our American friends. This is one fairly high priority mission in the American programme, as we were told a few weeks ago.

Finally, another element of this programme, an ambitious one, is this mission here [*un ulteriore lucido viene messo sul proiettore*] which is, if you like, the counterpart of the x-ray mission, which I described a few minutes ago. This is a far infrared telescope [57], 8 metres in diameter, operating between a few hundred microns and a few millimetres. This telescope, with a huge antenna and a huge cryostat, has the ability to observe the cold Universe, but it has another interesting property, in terms of cosmology, which is that we can measure the deviation from the spectral distribution of the cosmic background. In particular, when a photon of the cosmic background traverses a cluster of galaxies, where there are fairly high energetic electrons: through inverse Compton scattering [58], the electrons transmit part of their energy to the photons of the cosmic background, which are shifted in wavelength. This shift, if correctly measured, can give you the temperature and the density of the cloud; if you also measure this temperature and this density with x-ray missions, as I discussed a little bit earlier, then you may be able to determine the

[57] Si tratta della missione Herschel (in onore degli astronomi Caroline e Wilhelm, scopritore di Urano, 1781), già precedentemente denominata FIRST (Far InfraRed and Submillimetre space Telescope). Il satellite, lungo 7.5 metri e dotato di un telescopio con specchio primario di 3.5 metri, dovrà fare osservazioni tra 60 μm e 670 μm per permettere di studiare la formazione ed evoluzione di stelle e delle prime galassie. La vita prevista è di 3+1 anni. Considerato uno sviluppo di ISO, ed inizialmente programmato per il 2007, è stata poi riprogrammato per il luglio 2008. Sarà lanciato con razzo Ariane 5, insieme al satellite Planck per lo studio del fondo cosmico di radiazione a 3 K. Ambedue i satelliti andranno a collocarsi nel punto Lagrangiano L2.

[58] Com'è noto, l'effetto Compton riguarda l'urto elastico tra un fotone ad alta energia ed un elettrone. Nell'urto diminuisce la frequenza del fotone e l'energia così persa si converte in energia cinetica dell'elettrone. Il fenomeno fu osservato da Arthur Compton nel 1932. Se invece l'energia del fotone è molto più piccola di quella dell'elettrone, viene generato un fotone ad alta energia (effetto Compton inverso): è uno degli effetti da cui ha avuto inizio il dibattito sulla dualità onda-particella.

dimension of the cloud and its distance from the Earth. Therefore the Hubble constant can be measured directly with a precision which has been predicted to be on the order of 10% as compared to the 100% [59] of uncertainty that is now the uncertainty of this mission. Again there is a very strong cosmological interest in this mission, which puts together the big Universe and the tiny Universe of particles.

I would like to stop here and tell you that these are a few examples of what we can do today from space. Space astronomy, and space research in particular, is one of the most dramatic improvements and leaps in the progress of science that we have been able to witness in the second part of our century. And I think that we have shown, and we will prove in the future too, that without space there is no possible scientific progress, and I think, having said as much, I look forward to some seminar of this kind when, in the year 2010, we analyse the findings of these missions.

Giancarlo Noci

I would like to comment that we are all interested in the research subjects you have suggested, and in increasing the budget of the scientific programme rather than in decreasing the ambitions of the scientists.

We shall now have some shorter contributions from people who have been active in the early days of the space research and in more recent times.

Hendrik van de Hulst

Ladies and Gentlemen, I hope I can be brief. The title of this little intervention is "Erasmus and ESA". I have to write a few words and citations, but one of the keywords is: [*scrive alla lavagna*] "Stultitia" and then "Filautia", "Kolakia" [60]. Let me immediately give this citation: [*scrive alla lavagna*] "ridenda magis quam foeda recensere studeamus".

Now, Erasmus [61] was a true European and his name is now honoured by the name of the University of Rotterdam and by a Trans-Europe express train, but he actually travelled a lot and he earned the doctor's degree at the University of Torino [62]. In England he tutored the children of the

[59] *Sic.*

[60] Scrive queste due parole in alfabeto greco: Φιλαυτια – Κολακια ("Amore di sé", o "Vanità", e "Adulazione").

[61] Desiderio Erasmo da Rotterdam: pseudonimo di Geert Geertsz (1466-1536), umanista e teologo olandese.

[62] Fu in Italia dal 1506 al 1509. Erasmo aveva frequentato l'Università di Parigi, famosa per l'insegnamento scolastico, ma divenne dottore in Divinità (ossia in Teologia) all'Università di Torino all'inizio del 1509.

physician of Henry VII and with those children, as a tutor, he travelled to Italy for the first time. He must have seen the Duomo in Firenze when it had been finished for less than a century [63] and when it was still clean. He was a true Renaissance man and wrote several books with quotations from Latin and Greek authors. Of course, Europe was more European than it is now, in terms of language: there was only one common educated language, which was Latin, and it was only Galileo about a century later who thought up the idea that it would be good to use the people's language.

However he is most famous for the "Praise of folly", the "Stultitiae laus" [64]. I have wondered whether this "stultitia" in English would be translated as "folly", or as "madness", or as "stupidity", or as "silliness" and it has all kind of notations here, but Beppo kept referring to Erasmus at many ESA meetings, when we met, and I thank you [*rivolto verso Beppo Occhialini*] for making these references and finally arousing my curiosity so much that I started to read it. And in the same way that Erasmus explains in his dedication-letter to Thomas More [65] of this book, when making the trip form Italy back to England, where he hoped to see many friends, while riding on horseback, doing something very serious, he felt, was not the most suitable thing and he wanted to do something lighter: so then he conceived that book. In reverse, yesterday travelling to Italy I took that book on the train from Leiden to here, and I read it, and now I present it to you [*porge a Beppo una copia incartata del libro, tra gli applausi. Beppo va alla lavagna e, senza parlare, scrive a sua volta: "Gerard = Erasmus = Lovable"* [66]*, poi torna a sedersi*].

I still have to place a little more substance in this and, of course, this [*indica la frase in latino alla lavagna*] citation is from the dedication-letter to Thomas More and it says: "We have tried to review the ridiculous rather than the ugly" and one might try, in doing a kind of a critical review of European Space Research, to take that as a motto of a future book.

I have to explain these few words: "stultitia" is, of course, the folly and what example do we have of it? Well, first of all, it is an act of bravery: Stultitia, who is the goddess explaining all this in this book, telling us here of course that whatever heroic deeds have been done on this Earth, have always been done through sheer stupidity, because people are fool-hearted and don't even know what they are getting into. The same thing, of course, was true of early space research; the big break which created

[63] Il Duomo di Firenze fu finito verso la metà del XV secolo, ma la facciata fu lasciata grezza e venne terminata soltanto tra il 1871 ed il 1887.

[64] Trattato religioso. Fu scritto nel 1509, ma pubblicato solo nel 1511.

[65] Noto in Italia come Tommaso Moro (1478-1535), scrittore e politico inglese, alla corte di Enrico VIII.

[66] Occhialini usava chiamare van de Hulst "Erasmus". Erasmus deriva dal greco Erasmiòs, amabile.

so much optimism at that time was the so-called transatlantic factor, that we in Europe could do things not only better and faster, but we could do them cheaper by a factor three. The most optimistic point was when we had this committee looking into what the "second large project", after the large astronomical satellite, would be and spending long meetings on that. Then, just about half a year before starting, we found out that we didn't even have the money for the *first* large project.

Also, at the same time we had a launching programme advisory committee [67], consisting of four people. I forget now the names of those persons, but I do remember that once I tried to characterise that committee as consisting of one man who was irresponsibly optimistic, one who was irresponsibly pessimistic, one who was irresponsibly stupid and one who was irresponsibly clever. These four people together made up a perfect committee!

Now the "Filautia" is of course not "Philosophia", it is not love of wisdom, but is love of oneself. Erasmus, "Stultitia" in his book, explains quite well that no science is possible without self-esteem. One would never go through the hardship of doing science without really being convinced that it is important and that one's own contribution to it is important. If Erasmus had known non-Euclidean geometry, which of course he didn't, then he would perhaps have explained the curvature of psychological space, which works this way: the three angles of a triangle together add up to 180 degrees, only when the triangle is a plane triangle; but you can easily construct a spherical triangle, whose three angles together are 270 degrees or even up to five times as much as 180 degrees [68]. Well, in the same way, if you interview the people who have contributed to one of those co-operative projects and ask each of them what percentage he contributed, you may come up with 500%. That is the curvature of psychological space. That's really [*indica Filautia sulla lavagna*] this!

Now the final point is "Kolakia", which is translated as pedantry or flattery. I think the most appropriate expression in modern society is "mutual admiration society". And that is very important to keep up morale at a time when everything seems to go wrong. We have had many of those times in many of those projects which have been described here. Erasmus has a beautiful description of that, and there is an illustration of Hans Holbein [69] of that situation, which is: "What gives better service than

[67] LPAC (ESRO). Vedi nota 78.

[68] Su una sfera di raggio R, un caso semplice è quello di un triangolo formato da una figura a tre vertici, dei quali due sono ai poli ed il terzo, per esempio, sull'equatore. Quando si muove questo punto lungo l'equatore in modo che l'altezza sia uguale a $2\pi R$ (o, in generale, al parallelo locale), il triangolo degenera e si verifica l'affermazione di van de Hulst.

[69] Hans Holbein il Giovane (1497-1543), pittore ed illustratore tedesco. Attivo alla corte di Enrico VIII, fu celebre ritrattista e dipinse anche lo stesso Erasmo.

service… [*passa al latino*] Quid autem officiosius, quam cum mutuum muli scabunt?"[70], which is: "What renders better mutual service than when two mules scrape together?". So that is a good description, I think, and at the end of the book, Stultitia says that if people have certain criticism – never mind, I don't even remember what I said. In that respect, if Erasmus had known modern electronics, he might have explained the principle of the superheterodyne in scientific organisation. It is good for you to know that, in electronics of course, you have these different steps of amplification, and early on one found out that if there was just a little feedback from the last step to the first step, then that would start to generate a signal the same way it generated here [*indica il microfono*] a moment ago. The way to avoid that is to have changed frequency in the meantime. In the same way, you can explain that in any organisation you should never admit any person to an office, who knows why a certain decision was made ten years before.

Jacques Labeyrie

[*Cerca di capire se il microfono ha effetti di risonanza*] No, nothing happens…

People have been giving talks on Physics, now I would like to give a rather brief talk, a story of speleology. "Speleology" comes from "speleos", an ancient Italian word[71], I guess, which means "cave" in English [*lo scrive sulla lavagna*]. When I met Beppo for the first time, it was in 1949, in August 1949 in the Pyrénées, I was a very young beginning physicist at that time. Beppo had a kind of aura – do you say 'aura' in English? – a kind of glow, a reputation as a very great physicist who had discovered the positive electron and the π meson, just before we met, and he also discovered and explored the cave of Corchia near Carrara[72] in Italy, which was the deepest hole known in the world at that time, half a kilometre or so.

So I was very impressed to meet such a great man, and I saw Beppo arriving one evening in August in this small hotel in a very small village in the Pays Basque in France. Pays Basque is here [*traccia uno schema geografico elementare alla lavagna*], this is Bordeaux, here, this is the Spain border, and Pays Basque is here, in this region. The village was Licq-Athérey and there are very large deposits of Cretaceous limestone

[70] Citazione dal paragrafo 44 del "ΜΩΡΙΑΣ ΕΓΚΩΜΙΟΝ sive Stultitiae Laus".

[71] In realtà l'etimologia della parola è greca e viene dal termine "spelaìon", grotta.

[72] Il monte Corchia è vicino al comune di Stazzema (LU). L'Antro del monte era stimato avere una profondità di circa 700 metri, ma negli anni '80 si è scoperto che fa parte di un sistema di cavità che scende a 1200 metri.

on the border in the Pyrénées; we suspected at that time that probably there were very deep holes, very big caves, in this big layer of limestone. We suspected that we could perhaps find 100 meters more than in the Alpi Apuane, where is Corchia.

This is a second aspect of Beppo, you know, he was very excited, I suppose, at the idea of finding deep caves in that region of France, of Pays Basque. And me too, of course. So in 1949 we found nothing, nothing; then in 1950 we found nothing, except that the last day of our holidays – it was during the holidays that we were doing that, of course – the very last day of our holidays of 1950, Beppo and another guy, named Lépineux [73], were taking some stones out of a fissure, a small hole, and they found something which looked very great. We put some probes, we probed it with a football and a very long string, and we found that probably there was a hole of something like 350 metres in depth.

The following winter was spent building a machine to bring people into this hole, in order to look what was at the bottom of this hole, and the next year, in 1951, some people of our team explored it and discovered that probably it was at least equal to the Corchia pit. It was the Pierre St. Martin hole, which became famous in 1952 because one of the people of our team was killed in it. It was during holidays and the newspapers spoke a lot of it, therefore the hole became famous.

So in fact Beppo was there, at the very point where the discovery was made; it was in fact made by him because he opened the hole which had been closed since Cretaceous times: he was one of the two men who opened it. I would like now to explain, just briefly, that Beppo had a special gift; we were three physicists in this team, exploring these caves in the Pyrénées. One of them was Beppo, one was a man famous also because he liked to go very high in the atmosphere or very deep in the sea and also very deep in the Earth. He was obsessed by verticality, he was interested in vertical digs and caves [74]. Unfortunately, he pretended that he was a skilled mechanic, and he constructed machines to go up to the sky, into the sea, into the Earth, vertically, and we had confidence in him, unfortunately. In 1952 we used a winch constructed by this man, to go down in this shaft. The Pierre St. Martin hole was like that [*disegna alla lavagna una sezione della cavità*]. Here is the pit and, at the bottom, there is an enormous room here, like that, and another enormous

[73] Georges Lépineux , speleologo francese. Nel 1951 lui, Marcel Loubens e Haroun Tazieff condurranno la prima esplorazione delle grotte, alla quale si accenna subito dopo.

[74] Max Cosyns (1906-1998) fisico e speleologo belga. Nel 1932, come assistente del famoso fisico ed esploratore svizzero Auguste Piccard, compì un'ascensione scientifica in pallone fino a 16200 metri. Giuseppe Occhialini collaborò con lui alla creazione del Centre de Physique Nucléaire dell'Università Libera di Bruxelles.

room begins here, and an enormous room here, and so on [*disegna una successione orizzontale di caverne*] for 7 km or so, million-cubic-meter rooms... But that year we had to explore only the first two and later we discovered other caves in the upper part of this system. So this man, this lover of verticality, had made the winch of the 1952 expedition, it was set here [*segna un punto all'imboccatura della cavità*] and it worked very badly. It stopped for some reason or another, so it took a very long time to go down to send a few people to the bottom of the cave. When the first one came up, the cable broke and the man died[75]. When we took up one of the last men, three or four days later (we had stopped the expedition because of that accident and we came back up), one of the last to be extracted from the hole was Tazieff[76], the vulcanologist who was with us. He was part of this team and unfortunately, the winch stopped when Tazieff was there [*mostra il punto sul disegno*], with a small cascade of ice and water dropping on him, and he spent few hours there and nobody was able to repair the winch. We could not repair the winch because nobody was able to diminish the traction on the cable; the steel cable was still greasy, nobody was able to find a system to take the cable, to diminish the effort on the winch, you see, in order to repair the winch. So, it was very dangerous for the poor Tazieff, since for about a quarter of an hour no sound had come from him; we had a microphone here, he was like dead. So, we were there, Beppo was there too, and finally he first found the solution to the problem. He finally said: "Oh, Prussic!![77]". I supposed it was a German interjection, but it was the name of a very famous knot. This the cable and the knot is like that [*cerca di disegnarlo sulla lavagna*], so if you make a traction on this, you can exercise a very high tension in that sense, and so we can take a grip on the cable to hold it. Then twenty people or so went down, there was a lot of journalists attracted by the death of our poor, of this poor guy before, and the people took the cable with Prussic knots, twenty people about, and so we were able to diminish the effort on the winch to repair and to take Tazieff out of the hole.

So, you see, Beppo appeared to have a very strong sense of practical mechanics, as opposed to this physicist who constructed the winch, who had no sense of mechanics at all.

[75] L'uomo dell'incidente è il già ricordato Marcel Loubens e la voragine, che ha preso il nome dallo scopritore ufficiale, Lépineux, è profonda 320 metri.

[76] Haroun Tazieff (1914-1998) famoso geologo e vulcanologo francese d'origine polacca.

[77] Prussic o Pruzik è un tipo di nodo scorsoio, ad ampiezza variabile, che forma un cappio attorno ad un'altra corda e lungo la quale esso può scorrere quando è allentato. Ufficialmente introdotto nel 1931, in pratica serve ad afferrare una corda con un'altra corda.

Jean Dinkespiler

If you want to find somebody who doesn't understand why a previous decision has been made, you choose somebody from another field, and this is what the organisation did when they appointed me as a director of a programme. I was not a scientist. I'm still not a scientist, so I know nothing, and one of the members of LPAC [78], who is not here today, said to me: "You are not a scientist, so you will have no preference".

This how we started from inside the organisation, trying to understand what the scientists wanted for their missions, and I see from Prof. Bonnet's presentation that we still try to do that. It was a difficult task, because the situation, for my eyes of engineer, was a difficult one. I was told that there was one scientific community, and I soon found out that there were several scientific communities. Mainly at that particular time, exactly 20 years ago, in 1967, there was a group, a very numerous group of those who were tempted by missions in the solar wind area. There were many, many scientists who wanted to have as many measurements of as many parameters as possible in as many points in space and time as possible. They were in fact menacing, threatening to saturate our computers. On the other side, there was a smaller group of people who said they would be content with studying one photon per day or one photon per fortnight in the gamma range or, later, in the x-ray range, and for technicians that was more comfortable. You could see on Prof. Lüst's Table, a moment ago, that the load on the telemetry was much lighter; I knew nothing about that and the best I could do was to try to understand something, and in order to help me to understand something, there was LPAC.

About three months after I joined, exactly during the Christmas recess of 1967, I got a telephone call: "My name is Occhialini, I would be happy to meet you". He was among the ones, who were asking themselves questions about this non-scientist, this strange animal coming from a different planet. He arrived in his ESRO headquarters around 3 p.m. and started putting questions, I mean, firing questions at me; it was the longest exam of my whole career. At 8 p.m. I called Marianne and she said she would add water to the broth. We went home and I was still submitted to his questions until three o'clock in the morning. This is true.

[78] LPAC: Launching Programmes Advisory Committee. Il compito di questo comitato, formato da sole 4 o 5 persone e presieduto da Lüst nel periodo considerato, era di definire un programma di lanci di sonde e satelliti in base alle proposte presentate dalla comunità europea della ricerca spaziale. I criteri di selezione erano la pertinenza scientifica, la fattibilità tecnica e le risorse finanziarie; le conclusioni erano da sottoporre al STC: Scientific and Technical Committee. Il LPAC decise di definire delle aree tematiche identificate da sigle: ATM (Fisica e Chimica dell'Atmosfera), ION (Ionosfera ed Aurore), SUN (Fisica Solare), PLA (Pianeti, Luna, Comete, Mezzo interstellare), STAR (Stelle e Sistemi Solari) ed infine COS (Raggi Cosmici e Radiazione Intrappolata).

Apparently the overall balance of the exercise was rather on the positive side, because from that day on, Beppo tried to help me, whenever he could. We had many opportunities to have discussions, and when I say discussions… well, I'll try to describe that later on. In particular, we had a very close relationship, I must say, and it became perhaps a little emotional, because of the tension of crises, we always had crises, we had repeated crises and we were trying to get out of that, and the atmosphere was very tense.

He used to come and every time he had a message. What message? The message was very difficult to grasp, the message was delivered in a coded language. He quoted Greek philosophers, poets, Shakespeare, a lot of Shakespeare, TS Eliot, Victor Hugo, André Chénier and others. He had a liking for geniuses, I must say, but he also quoted *The New York Times*, *The Manchester Guardian*, for historical reasons, I suppose, or for specific reasons in his experience. He quoted *Le Monde*, substantially he quoted François Mitterrand, who was still an unsuccessful candidate, and he left my office and I had to find out what the message was. It took me one or two days or even more, and there were always one, two or more messages, and this lasted as long as we worked together in the organisation, something like seven years. Then I left the organisation, but we remained in contact. We have had many meetings since then, and I still consider Beppo as my "maître à penser", as my spiritual father, if we want to put it that way.

And for me, I have to apologise to the many Fiorentini, who are in this room, but for me the centre of Tuscany is not Florence, is not Siena, San Gimignano or Pienza: it is Marcialla[79], near Tavarnelle. That is the most important place in Tuscany.

Ernst Trendelenburg

Arriving in Tokyo, 1967[80], after a twenty-hour flight, you get out of the cafeteria of that hotel and you run into Beppo, you want to hit the sack, as one says in English, as you want to sleep, and Beppo ask you whether you had something to drink and – yes , I had some 50 cc of French cognac, bought at Amsterdam airport. So Beppo said: that is a hell of a cognac and that was at about 8 o'clock Tokyo time, and it ended up to 5 o'clock in the morning. The bottle was empty, the carton of cigarettes was

[79] Località nel Chianti dove era il cascinale in cui Occhialini si era ritirato. Si veda A. Russo, "Vita di uno sperimentatore", *Sapere*, vol. 62, n. 3 (giugno 1996), p. 68.

[80] In realtà 1968. Vi fu una riunione ristretta del LPAC, per discutere gli esperimenti sui satelliti TD, in occasione del 9° Simposio COSPAR (maggio 1968). Trendelenburg vi partecipò come direttore di ESLAB (European Space Research Laboratory).

also empty and I have become totally convinced that I am a total crook. I think all Beppo's friends are crooks. They have been accused of being crooks, but I think they are lesser crooks than other crooks, because you are always reminded that there is a man of intellectual integrity: Beppo; you always ask yourself if it is right what you are doing, and then you want to reflect. Therefore I want to say: Beppo, thank you very much for your friendship.

[*Alla fine degli interventi dei membri di ESA, Noci passa la presidenza della seduta a Blasi*].

Paolo Blasi

I want to read a telex coming from Hermann Bondi, who could not attend this meeting.

"I'm delighted to know that you all have taken the opportunity to have a jolly meeting on the grounds of Beppo Occhialini, pretending to have left his first youth behind. I am sorry that I cannot join you but I am full just thinking of your meeting. I know it is many years since I had much contact with him, but how can I recall those times without still smiling at the recollection of our meetings? Always irreverent, always irrepressible, always full of enthusiasm and determination, always full of how to get the best science out of what ESRO could offer. He was a tonic for me, every time. True, he gave me sometimes a worth task to carry out, but then I knew that my job was to ensure that good science was done, and doing what Beppo wanted me to do invariably meant that I was working for science and thus I could do it with a light heart. May his youthful zest and optimism continue to combine with his creative science for many more years. Good luck to you all".