1949 sarebbe stato stampato con il titolo “Albert Einstein: Philosopher-Scientist”. Il volume era una raccolta di saggi, appositamente scritti da scienziati e da filosofi, che mettevano in luce, sotto angolature diverse, il grandioso impatto culturale del pensiero einsteniano.

Che fare, allora? Personalmente ritengo che sia accettabile l’opinione di uno storico della cultura come Paolo Rossi, secondo il quale una persona è colta se, oltre ad apprezzare Shakespeare, sa anche cogliere il significato di una legge fisica.

C’è molto da fare, qualora si accetti davvero questa regola. E, soprattutto per i giovani, c’è da rivendicare con orgoglio l’eredità di Galilei ed Einstein. Galilei pretendeva per sé il titolo di filosofo, ed Einstein amava dire che la scienza senza filosofia è arida, e che la filosofia senza scienza è vuota. La ricerca di base è cultura in quanto è guidata dalla curiosità, e la curiosità per i fenomeni osservabili è la matrice non della tecnica, ma di quella che in età galileiana si chiamava “filosofia naturale”, e che oggi può prosperare solo nella libertà.

The role of Ion Beam Analysis in environmental studies

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Ion Beam Analyses (IBA) – such as PIXE (Particle Induced X-ray Emission), PIGE (Particle Induced Gamma-ray Emission) and PESA (Particle Elastic Scattering Analysis) – have been applied to many different fields due to their high sensitivity, multi-elemental capabilities and non-destructive character. One of the many research fields that made use of IBA as an analytical technique was related to environmental studies, and in particular to atmospheric aerosols. Atmospheric aerosols play an important role in the physics of the atmosphere; they act as clouds condensation nuclei, are responsible for visibility reduction, contribute to global change and carry on a number of toxic metals inducing adverse health effects. Moreover, atmospheric particles contribute to the damage of cultural heritage.

In the frame of the aerosol research, the most interesting property of PIXE is that it provides quantitative analysis of elements which are markers for specific components or sources of particulate matter such as marine aerosol (Na, Cl), mineral dust (Al, Si, Ca, Ti, Sr), sulphates (S), biomass burning products or biogenic emissions (K, Zn, Rb), heavy oil combustion (V, Ni), incinerator emissions (K, Zn, Pb), traffic and industrial emissions (Mn, Ni, Cu, Zn, Pb). The knowledge of suitable markers for each emission source is very helpful in the application of statistical multivariate analysis such as receptor models (PCA, APCA, PMF,…) that lead to the identification and quantification of the contribution due to different emission sources.

The complementary use of PIXE and other IBA techniques such as PESA (for the determination of H, C, N, O), PIGE (for light element analysis) as well as chemical analysis (for the speciation of carbon compounds and for the quantification of the ionic content) allow a complete aerosol characterization and the possibility of a mass closure [1]. A typical aerosol sample consists of a thin layer of particles deposited on a filter support, its total thickness ranges from a few hundreds of $\mu g/cm^2$ up to 1 mg/cm^2 and it can therefore be considered as a thin target for energetic proton beams of a few MeV.

The yields of X-rays, gamma-rays and scattered particles after a few minutes of irradiation by some tens of nA of 2-4 MeV protons are generally sufficient to provide elemental concentrations for almost all the elements of interest for atmospheric aerosol studies. PIXE and complementary ion beam analytical techniques were implemented in the past by the authors for atmospheric aerosol studies at the INFN external beam facility in Florence, based on a KN3000 Van de Graaf accelerator [2] and, recently, at the new INFN-LABEC facility based on a Tandetron accelerator. PIXE analysis allowed the determination of elements with Z >10 which are generally detected in aerosol samples by routine analysis with Minimum Detection Limits (MDL) of the order of few (1–10) ng m^{-3} for most elements.

A problem with PIXE analysis is the X-ray self-absorption in the particulate matter deposit or in the single particle. The self-absorption effect influences especially the quantitative analysis of low atomic number elements (i.e. Na, Mg, Al, Si) and needs the introduction of correction factors generally calculated theoretically. Advantages of PIGE and PIXE contemporary application are – apart from the low Z elements detection to reach a complete mass balance – the possibility of determining experimentally the self-absorption correction factors which are essential to provide correct PIXE concentrations.

The application of PIXE/PIGE is mandatory when high-time resolution samples or size-segregated samples are of interest as they give the possibility of having an ion beam of reduced size and a good sensitivity also with small quantities of matter. High time-resolved and size-segregated samplings give insights into physical-chemical processes involving aerosols (production, transformation, transport, removal) and allow a direct comparison with gaseous pollutants and meteorological parameters, which are often monitored on an hourly basis. Time-series of hourly elemental concentrations have been obtained by our research group during previous monitoring campaigns at locations with different characteristics (urban, industrial,...) [3].

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The experimental set-up for PIXE/PIGE analysis is shown in Fig. 1. Since X-ray production cross sections ranges over 3 order of magnitude, to obtain an efficient simultaneous detection of all the elements it is necessary to balance the counting rates of the different X-rays. The adopted solution is the use of a quite high beam current (5-15 nA) and two Si(Li) detectors (Si1 and Si2 in the Fig. 1), optimised respectively for low and medium-high X-ray energies. Moreover, helium gas flows into the volume in front of the detectors to reduce the possible attenuation of low energy X-rays by the air. A HPGe detector is used to collect the γ rays for PIGE analysis. For aerosol samples the total thickness (aerosol deposit + substrate) is small enough to let the beam pass through; as a consequence the charge can be measured simply integrating the beam charge on a graphite Faraday cup (FC) placed behind the sample.

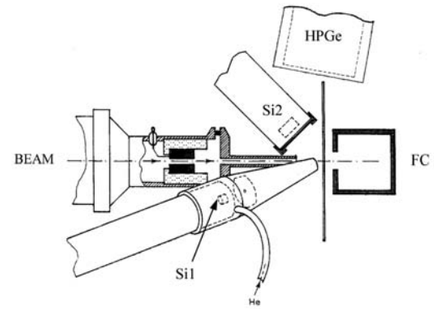

Fig. 1
KN3000 external PIXE-PIGE set-up at the INFN Van de Graaff accelerator of the INFN in Florence

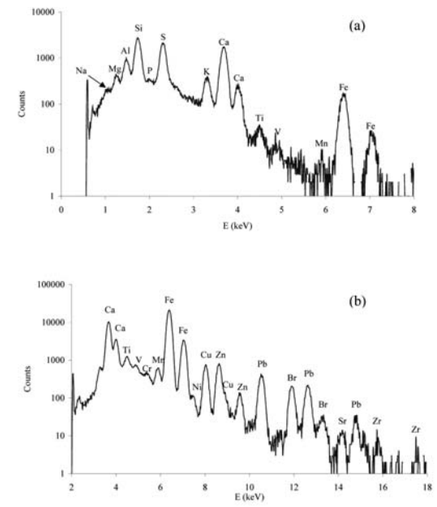

Fig. 2
PIXE spectra from a sample of aerosol, recorded simultaneously by Si1 (a) and Si2 (b).

A 2.990 MeV proton beam has been used so that the cross section for the Na(p;p'γ)Na (E = 440 keV) reaction, which is exploited for PIGE determination of Na [4], remains sufficiently constant even considering the moderate proton energy loss in the sample. Moreover, the beam energy is high enough to provide good sensitivity for PIXE. PIXE and PIGE analyses are now routinely and simultaneously performed by our group both on 1-hour resolution fine and coarse aerosol samples and on standard 24-h particulate matter deposits.

In order to allow a complete reconstruction of the aerosol mass, we implemented the light element (H, N, O and C) detection by means of in-vacuum Particle Elastic Scattering Analysis (PESA) with 3 MeV protons on particulate matter collected on Teflon filters. For the PESA measurements we used two fully depleted surface-barrier detectors arranged at forward and backward angles in a vacuum chamber. The detector used to measure the H content was placed at a scattering angle 30° while the other detector, used for the C, N and O concentration determination, was placed at 150° and the sample was placed in a vertical plane orthogonal to the beam. The beam current was integrated, after the sample, by a Faraday cup, kept at a positive voltage of about 70 V to avoid secondary electrons escape. [5]

Since mass resolution improves at higher beam energies, we selected the working ener-

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gy in the highest proton energy range available at our Van de Graaff accelerator. To obtain quantitative results by direct comparison with thin standards, we worked at an energy of 3 MeV, where the proton elastic scattering cross sections on H, C, N and O are quite constant (better than 10%) over the range of proton energy loss in aerosol samples (≤ 100 keV). The calibration was achieved using a thin Upilex-S foil containing known areal density of H, C, N and O; the energy loss for 3 MeV protons in this foil is 120 keV. Preliminary test measurements were also carried out to identify the best aerosol filter for these analyses and Teflon membranes resulted to be the only substratum appropriate for PESA analysis. Using Teflon filters PIXE and PESA analyses are both possible on the same sample, but at the moment they are performed separately.

The coupling of the PIXE/PIGE and PESA techniques allows the 'mass closure', i.e. the measurement of the concentrations of all the elemental constituents of atmospheric aerosol. An example of their application for mass closure purposes, is shown in Fig. 4; it concerns a first aerosol characterisation of the atmospheric aerosol in the industrial area of Montelupo Fiorentino [1]. The assessment of the detailed elemental composition on a wide data-set allowed also the application of receptor models and led to the identification of main emission sources and their contribution.

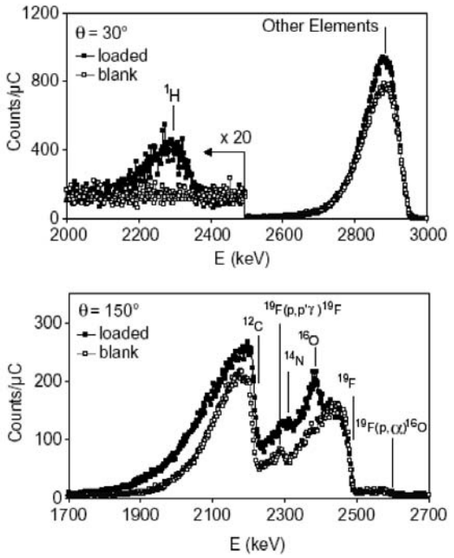

Fig. 3
Proton scattering spectra on blank and loaded Teflon filters, detected at an angle of 30° (above) and 150° (below).

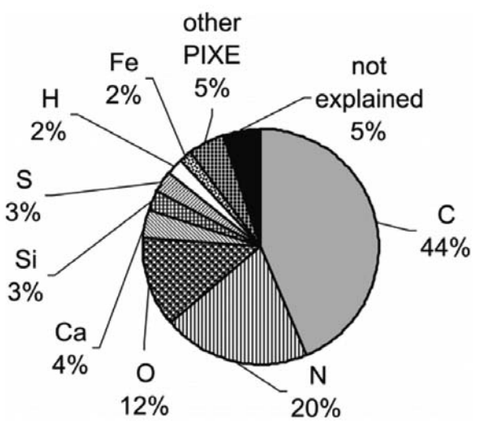

Fig. 4
Average contributions (in percentage) of the eight most abundant detected elements to the total PM10 mass.

Climate change and variability in Italy in the last two centuries

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The Italian monthly temperature (mean, maximum and minimum) and precipitation secular data-set was updated and completely revised. Station density and metadata availability were greatly improved and the series were subjected to a detailed quality control and homogenisation procedure. The errors affecting original data were quantified by studying the temporal evolution of the mean adjustments applied to the series, and examined in the light of the station history. The results stress the importance of homogenisation in climate change studies. The final data set was clustered into climatically homogeneous regions by means of a Principal Component Analysis. Yearly and seasonal trend analysis were performed both on regional average series and on the mean Italian series (ITA). The results highlight a positive trend, for mean temperature, of about 1 K per century all over Italy: it is generally higher for minimum temperature than for the maximum one. The progressive application of trend analysis shows that this behavior is opposite in the last 50 years, the maximum temperature trend being stronger than that of the minimum temperature. This has led to a negative trend in the daily temperature range that, for the last 50 years, has become positive. Precipitation shows a decreasing tendency, even if low and rarely significant, the negative trend being only 5% per century on a yearly basis. A complete discussion of the data, the methods and the results is presented in [1]. Figures 1 and 2 display the ITA yearly temperature and precipitation records.

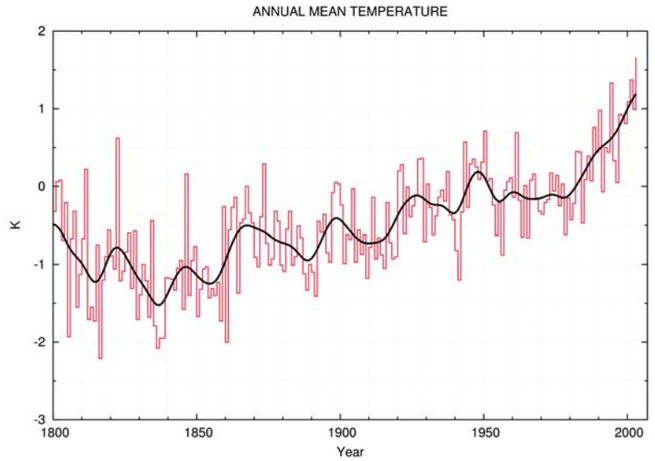

Fig. 1
Average Italian national series for mean temperature (1800–2003). The series is displayed together with an 11-year window 3-year σ Gaussian low-pass filter.

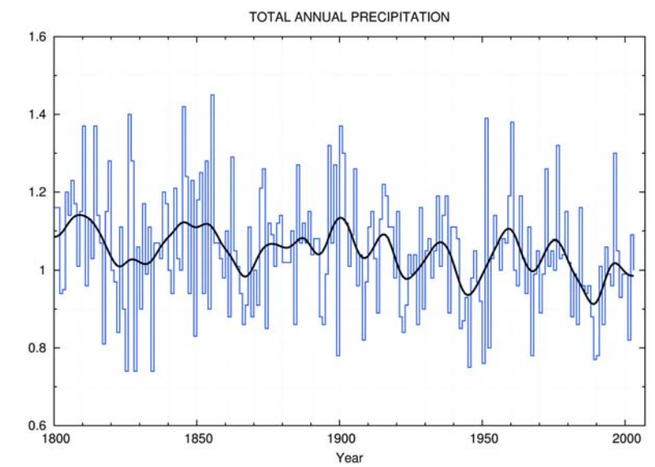

Fig. 2
Average Italian national series for precipitation (1800–2003). The series is displayed together with an 11-year window 3-year σ Gaussian low-pass filter.

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Natural radionuclides in the rocks of Valle del Cervo Pluton

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The radionuclides from ^{238}U and ^{232}Th series represent, with ^{40}K, the main source of gamma radiation in the continental crust. The specific levels are related to the rock types. Highest radiation levels are mainly associated with felsic rocks, due to the geochemical behaviour of U, Th and K. These elements are more abundant in the continental crust than in the earth mantle and prefer the liquid phase during a process of crustal anatexis (partial melting) and subsequent fractional crystallization. Valle del Cervo Pluton is a composite body consisting of Monzonitic, Syenitic and Granitic Complexes formed by strongly K-enriched rocks. The areas, where these rocks crop out, are characterized by high natural radiation background. Gamma spectroscopy at high resolution, with HPGe, is the most used technique for quantitative analysis of gamma emitters radionuclides. The following hypothesis has been made: 1- Isotopic ratio between ^{235}U and ^{238}U is 7,2‰. 2- ^{238}U and ^{226}Ra are in secular equilibrium. 3- The exhalation rate of radon gas has been determined to be less than 1% of the total radon contained inside sample's volume. This rate is not relevant for examination of radon's daughters. For all the analysed rocks the U concentrations are lower than the Th ones.The rocks of the Granitic Complex show the lowest contents in elemental Th, whereas the elemental U values are similar to those of the Syenitic and Monzonitic Complexes. The specific activity related to syenite PM 26 is particularly interesting: 764 Bq/kg for ^{238}U and 478 Bq/kg for ^{232}Th. This rock is the most active. Moreover, the syenite LB 99, collected at the *La Balma quarry*, shows specific activities of 468 Bq/kg for ^{238}U and 381 Bq/kg for ^{232}Th, respectively. These values are relevant compared with those of other granitoids used as building stones.

Concentration, composition and sources of PM1 (particulate matter with d<1 μm) in Italian urban sites

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In the frame of a national research project in 2004 we planned a monitoring campaign with the aim of characterising PM1 in three major Italian towns. This study completed previous researches on the PM10-PM2.5 characterisation performed by the authors in Milan, Genoa and Florence [1, 2]. The measurement campaigns were carried out in Milan, Genoa, and Florence using the same experimental methodology for sampling and elemental analysis (i.e. sequential samplers and ED-XRF spectrometry). Contributions from ionic components as well as elemental and organic carbon were also evaluated (by means of Ionic Chromatography and Thermal Gravimetric Analyzer/Fourier Transformed Infrared Spectroscopy, respectively). Gaseous pollutants concentrations and meteorological parameters were also available from the regional air quality network. In Milan, additional ^{222}Rn hourly measurements were performed to account for the stability/dispersion conditions of the atmosphere [3]. The PM1 mass concentration values were very high in Milan (wintertime median: 44.5 μg/m^3, summertime median: 19.1 μg/m^3), enhancing concern for possible health effects and problems in attaining the PM10 EU-limit. PM1 was about 40-60% of PM10 at the three investigated urban sites during both seasons. Aerosols of secondary origin (i.e. organics, nitrates and sulphates) dominated the PM1 mass at all sites accounting on the whole for about 80% of the mass. The application of receptor models allowed the identification of the emission sources and the quantification of their contribution to the particulate matter mass.

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