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SMALL ANGLE X-RAY SCATTERING EXPERIMENTS WITH THREE-DIMENSIONAL IMAGING GAS DETECTORS.

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Summary. - Measurements of small angle X-ray scattering of lupolen - R, dry collagen and dry cornea are presented. The experiments have been performed with synchrotron radiation and a new three-dimensional imaging drif-chamber gas detector.

The basic scheme of an experimental apparatus for measurements of small angle X-ray scattering (SAXS) includes an X-ray source, a collimation optical system, and an X-ray detector for collecting the radiation scattered from the sample. As usually the aim of a SAXS experiment is the measurement of weak scattering close to the incident X-ray beam (typically, scattering angles smaller than 5°for a radiation wavelength of 1.54 Å), the source brilliance B is required as high as possible. B is generally defined as:

$$B = \frac{\text{photons/sec}}{(\text{mrad})^2 \times (\text{mm})^2 \times 0.1\% \text{ band width}}$$

For this reason synchrotron radiation sources are the most suitable for SAXS experiments (Fig. 1)

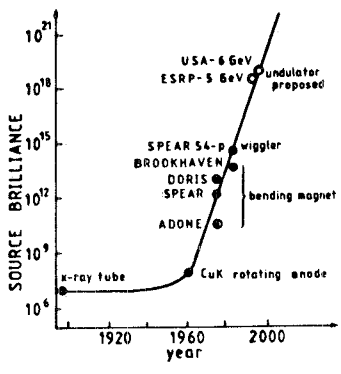

Fig. 1. - Increase of Brilliance of X-ray sources at λ =1.54 Å as a function of year

Depending on the structural properties of the sample to be studied, the shape of the scattered radiation intensity as a function of the scattering angle is either continous or discrete, as is shown in diffraction theory. The analysis of such shapes is very useful in order to determine several structural parameters of a sample having scattering units with dimensions of 20-10000 Å.

The scattered radiation is measured by an X-ray detector. An ideal detector should have high performancy both in space and time response. We propose to use the self-explanatory diagram shown in Fig. 2 in order to plot the significant parameters of any type of X-ray detectors for SAXS. In this diagram an ideal detector is plotted at the origin of coordinates.

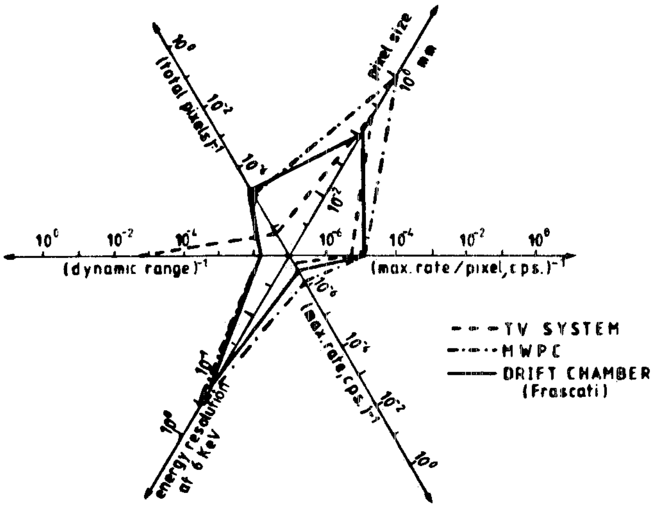

Fig. 2. - Diagram of significant parameters of SAXS detectors

For isotropic scattering, all the required information can be obtained by measuring the radiation scattered in one direction. In this case, the linear position sensitive detectors (PSD) are quite suitable for studying the shape of the scattered intensity. On the contrary, for anisotropic scattering (as is the case with fibres of polymers or chain molecules of byological substances) the performances of the most used two-dimensional detectors (photographic films,TV systems, etc.) are far from those of an ideal detector. Photographic films can only give qualitative information because of their small dynamic range (20-80). TV systems can be useful only for high scattering intensity because their responce is noisy and not uniform on the whole detecting area (due to the phosphor surface on the tube). Multiwire proportional chambers are potentially fine, but at present their response is not uniform on the whole detecting area (because of the wire structure), and their spacial resolution is not optimal.

Better performancies are presented by the two-dimensional detector developed by our group at Frascati since year 1980(1), and recently improved to the values given in Fig. 2.

We present recent measurements (Fig. 3, 4, 5, 6) obtained by using this detector on a diffractometer specially designed for SAXS experiments with synchrotron radiation (2).

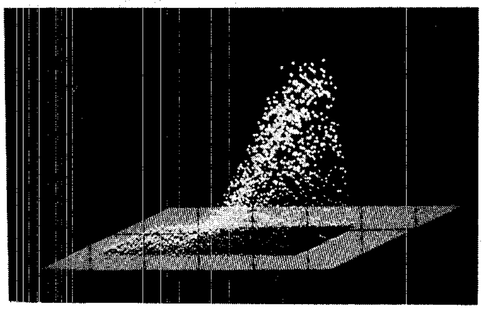

Fig. 3. - Three-dimensional image of lupolen-R isotropic scattering. Measured spherical radius of scattering unit R=155 Å. Recording time : 15'.

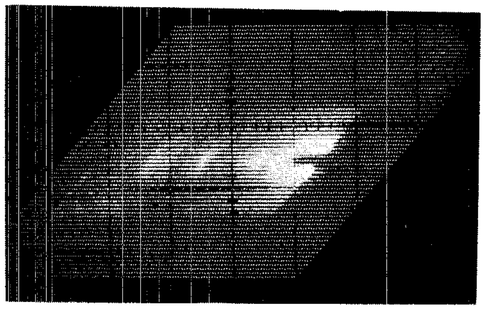

Fig. 4. - An example of two-dimensional image of dry collagen spectra. Fibre axis is parallel to detector's axis. Measured mean axial spacing : 670 Å. Recording time:60'.

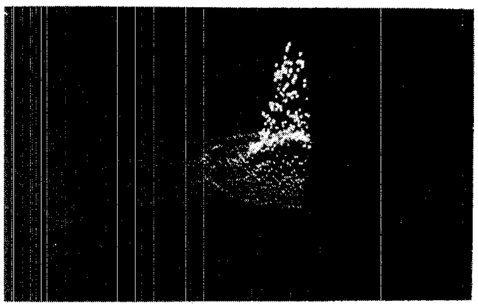

Fig. 5. - An example of three-dimensional image of dry cornea spectra. Measured mean spacing : 648 Å. Recording time : 90'.

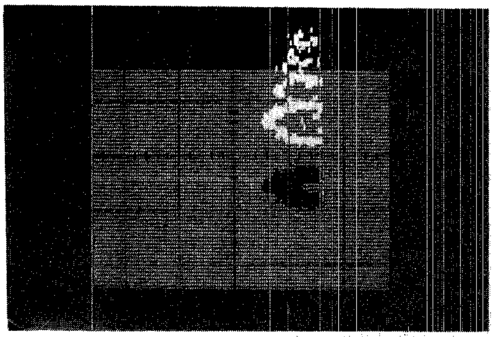

Fig. 6. - Three-dimensional image of cornea spectrum. The intensity is shown in logaritmic scale. Note the clear structure appearing in the region of diffuse scattering

All the results have been obtained with a brilliance $B \simeq 10^{11}$ (the same units as before) at $\lambda = 1.54$ Å, much lower than the brilliance $B \simeq 10^{13}$ used by other authors for their measurements with synchrotron radiation and photographic films on collagen and cornea (3, 4, also: Bigi A., Ripamonti A., Roveri N., private communication). Moreover the band width of our monochromator was 1.3×10^{-4}.

We wish also to note that, as far as we know, the clear three-dimensional gaussian spectrum of lupolen-R and the clear structure appearing in the region of diffuse scattering of cornea are observed for the first time.

Aknowlegments

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