5. International Workshop on Nuclear Resonance Scattering of Synchrotron Radiation: Status, Highlights, Methodology, and Trends
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BOOK OF ABSTRACTS
The nuclear resonance reflectivity (NRR) measurements provide us with an exclusive depth-resolved information about the magnetization ordering in multilayers. In the most NRR experiments the data are treated in terms of the definite magnetization azimuth angle for each magnetic sublayer in multilayer (e.g. [1-4]). Herewith it is covertly implied that each sublayer is magnetically homogeneous along the surface. But it is obvious and nowadays experimentally well proved that even ultrathin magnetic layers have domain structure up to magnetization saturation. If the beam spot on the surface is much larger than the average domain size and the scattering amplitudes from different domains are fully coherent we should get the pattern of random in plane distribution of hyperfine fields. However it is not the case (see e.g. [1]).

The new idea, which we now develop, is the necessity to take into account the finite transverse coherence length of synchrotron beam [5-6] which is essential for the large illuminated areas on the surface at grazing incidence. In this case the interference from different domains is partially suppressed by the factor $C_{coh}$ ($0 \leq C_{coh} \leq 1; C_{coh} = 1$ for fully coherent case). For $\sigma$- polarized SR ($\pi$- polarized magnetic field of radiation and hereinafter we work with the polarization of the magnetic field of radiation) the domains with different azimuth orientations of magnetization give the reflected waves of $\sigma$- and $\pi$- polarizations having different quantum beats in the $f_\pi(t)$ and $f_\sigma(t)$ decay dependences. It can be shown that in the kinematical approximation of the reflectivity theory $f_\pi(t)$ dependences are the same for all orientations of magnetizations but $f_\sigma(t)$ have the opposite sign for the inverse magnetization orientations along the beam direction. If the domain magnetizations have random orientations we can easily derive for the reflectivity intensity:

$$I_R(t) \propto (1 + 3C_{coh}) f_\pi(t)^2 + \frac{1}{2}(1 - C_{coh}) f_\sigma(t)^2.$$  \hspace{1cm} (1)

That means that for the fully coherent beam we have no $\sigma$- polarized contribution but for partially coherent case we have it. It looks like the magnetization in our sample have definite azimuth angle $\gamma_{eff}$ when the reflectivity intensity is described by the formula

$$I_R(t) \propto \left| f_\pi(t) \right|^2 + \sin^2 \gamma_{eff} \left| f_\sigma(t) \right|^2.$$  \hspace{1cm} (2)

By comparison of (1) and (2) we have got the formula which connects the obtained “effective” azimuth angle $\gamma_{eff}$ with the transverse coherence length of the synchrotron beam [5] in units of the average domain size. The separation of the “effective” azimuth angle onto the real magnetization direction and the part, stipulated by the partial coherence of the waves scattered be different domains, can be achieved by the measurements for different sample orientations. The difference of the magnetization directions obtained at two sample orientations opens a way for determination of the transverse coherence length of the synchrotron beam if the domain size is known and vice-versa: the average domain size can be evaluated if the coherence length is known.

References