Evaluation of 90° -Scattering Magnetic Compton-Profile method with High Energy X-Rays

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The cross section for the spin-dependent Compton scattering can be written in the form[1],

$$\frac{d\sigma}{d\Omega} = r_0^2\left(\frac{k'}{k}\right)^2\left[\Phi_0 + \Phi_1(P_L) + \Phi_2(P_C,\vec{\sigma})\right] ,$$

$$\Phi_0 = \frac{1}{8}\left[1+\cos^2\theta + \frac{\hbar(k_0-k)}{mc}(1-\cos\theta)\right] ,$$

$$\Phi_1(P_L) = \frac{1}{8}P_L\sin^2\theta ,$$

$$\Phi_2(P_C,\vec{\sigma}) = -\frac{1}{8}P_C\frac{\hbar}{mc}(1-\cos\theta)\vec{\sigma}\cdot(\vec{k}\cos\theta+\vec{k}') ,$$

$$f = \frac{\Phi_2}{\Phi_0+\Phi_1}\times\varepsilon ,$$

where P_L and P_C are Stokes parameters denoting the linearly and circularly polarized states of the incident x-rays, respectively. The symbol $\vec{\sigma}$ is a unit vector denoting the direction of the electron spin, and ε is a ratio between magnetic and total electron numbers.

The above equations suggest that if the initial x-rays are approximately linearly polarized ($P_L \sim -1, P_C \neq 0$) and the scattering angle is 90° , $\Phi_0+\Phi_1$ becomes extremely weak and the spin-dependent factor Φ_2 becomes a dominant term. This situation is advantageous for magnetic compton-profile (MCP) measurements.

A MCP measurement on polycrystalline Fe at a 90° scattering angle has been carried out by using 274 keV approximately linearly polarized x-rays at the BL08W, where the wiggler was operated with K_x=0.9 and K_y=11.2, and resultant P_L and P_C on the axis were -0.9 and 0.3, respectively.

An experimental f-factor at θ =90° was evaluated to be 4.2%, which is higher than that of an ordinary backscattering method (1.5% for 274 keV circularly polarized x-rays and θ =144°). It should be noted that the momentum resolution at θ =90° is likely to be lower than that at θ =144° : the divergence of the scattering angle $\Delta\theta$ induces the slit of the Compton-peak energy ΔE_C through the relation, $\Delta E_C \sim \frac{E^2}{mc^2}\sin\theta\Delta\theta$, where E is the incident energy of X-rays. As a result the dip of MCP of Fe around P_Z=0, which is observed at θ =144° , was almost smeared. To improve the momentum resolution, it is to narrow the slit in front of the detector. It is necessary indispensable to increase the incident photon flux, as the scattering intensity is weak at θ =90°

1)F.W.Lipps and H.A.Tolhoek:Physica **20** (1954) 85,395.