Development of Neutron Interferometer using polychromatic mirrors

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Neutron interferometry is a powerful technique for studying fundamental physics. A large dimensional interferometer for long wavelength neutrons has the advantage to increase the sensitivity to small interactions. Such a kind of interferometer was realized by using multilayer mirrors. We demonstrated Jamin-type interferometer for cold neutrons using beam splitting etalons (BSEs), which enables us to align the four independent mirrors within required precision [1]. The BSE contains two parallel mirrors. A couple of the BSEs in the Jamin-type interferometer separates and recombines the two paths spatially. A neutron supermirror is one of the multilayer with continuous latice constants, which reflects the wide range of the wavelength of neutrons. The BSEs with neutron supermirrors enable us to arrange Jamin-type geometory of the interferometer for white neutrons. The interferometer can be applied to pulsed neutrons by using the BSEs with supermirrors. Such interferometer increase the neutron counts for high precision measurements, for example, Aharonov-Casher effect. Wevelength dependence of the interaction in the interferometer also can be measured by the time of flight detection for pulsed neutrons.

As the first test we made polychromatic mirrors. The polychromatic mirror contained two multilayers with the different latice constants. The lattice constants were 15.8nm and 21.0nm respectively. We fabricated two polychromatic mirrors with intermediate gap layer on the top of Si substrate continuously. This device enabled us to provide two separated paths of the Jamin-type interferometer for two wavelength of neutrons.

The experiment has been performed using the cold neutron beam line MINE2 at the JRR-3 reactor in JAEA. The beam has a wavelength of 0.88nm and a bandwidth of 2.7% in FWHM. In the case of monochromatic beam of MINE2, the polychromatic mirrors functions at two Bragg angles. The interferometer can be constructed at the two incident angles. We observed clear interference fringes at the incident angle of 1.14 degree and 1.62 degree, which were corresponding to the two multilayers in the polychromatic mirror (figure 1).

Now we are planning to apply the supermirror for BSEs and to construct the interferometer for pulsed neutrons. We are also planning the experiments using the interferometer as one of fundamental physics investigations at J-PARC.

[1] M. Kitaguchi, et. al., Phys. Rev A 67 (2003) 033609

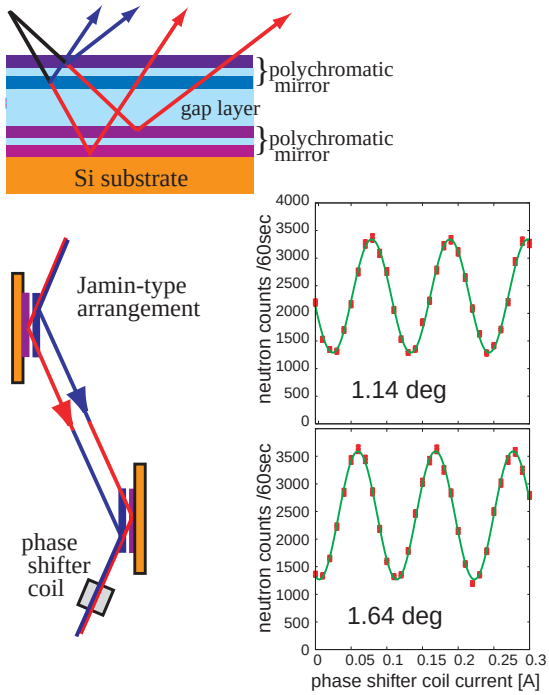

Fig. 1. Interferometer using polychromatic mirrors. Interference fringes are observed at two incident angles.