Analysis of neutron diffraction by optically thin grating

A study of a neutron diffraction experiment with nanoparticle-polymer composite gratings outside of the Bragg regime

Student:
Ismaele Vincent Masiello

Supervisors:
Simon Wall[1]
Jürgen Klepp[2]

A thesis presented for the master's degree in Physics

Department of physics and astronomy
Aarhus University
Denmark

Academic year 2021/2022

[1]Department of Physics and Astronomy, University of Aarhus, Ny Munkegade, Building 1520, DK-8000 Aarhus C, Denmark

[2]University of Vienna, Faculty of physics, Boltzmanngasse 5, 1090 Vienna, Austria

Analysis of neutron diffraction by optically thin grating

A study of a neutron diffraction experiment with nanoparticle-polymer composite gratings outside of the Bragg regime

Ismaele Vincent Masiello

Abstract

Holographic gratings have been used for decades in different fields such as acousto-optics, integrated optics, holography, and spectroscopy [1], and due to the development in the production techniques and the new materials available they have become a very efficient and fairly easily customizable component for both neutron- and laser- optics [2].

A diffraction experiment with such gratings can lead to substantially different outcomes depending on thickness and modulation profile. Bragg regime gratings, also known as thick gratings, predominantly produce only two orders of diffracted waves (0th and 1st order) and the relative diffraction efficiencies are well described by two-coupled-waves theories. However, outside of the Bragg regime thinner gratings generate higher orders of diffraction that are not neglectable anymore [3] and therefore a different model is needed [4].

In this thesis, a set of data from a neutron diffraction experiment collected between 2012 and 2013 at the Institute Laue-Langevin (ILL) [5] in Grenoble (France) is analysed. An attempt of analysis has been carried out using two-coupled-waves (Bragg regime) theories which did not yield acceptable results. The data clearly show the presence of non-neglectable higher orders of diffracted waves and therefore a multi-coupled-wave approach is implemented.

Bibliography

[1] M. G. Moharam and T. K. Gaylord. "Rigorous coupled-wave analysis of planar-grating diffraction". In: *J. Opt. Soc. Am.* 71.7 (July 1981), pp. 811–818. DOI: 10.1364/JOSA.71.000811. URL: http://opg.optica.org/abstract.cfm?URI=josa-71-7-811.

[2] Yasuo Tomita et al. "Photopolymerizable nanocomposite photonic materials and their holographic applications in light and neutron optics". In: *Journal of Modern Optics* 63.sup3 (2016). PMID: 27594769, S1–S31. DOI: 10.1080/09500340.2016.1143534. eprint: https://doi.org/10.1080/09500340.2016.1143534. URL: https://doi.org/10.1080/09500340.2016.1143534.

[3] T. K. Gaylord and M. G. Moharam. "Thin and thick gratings: terminology clarification". In: *Appl. Opt.* 20.19 (Oct. 1981), pp. 3271–3273. DOI: 10.1364/AO.20.003271. URL: http://opg.optica.org/ao/abstract.cfm?URI=ao-20-19-3271.

[4] Cristian Neipp et al. "Angular responses of the first diffracted order in over-modulated volume diffraction gratings". In: *Journal of Modern Optics* 51 (May 2004), pp. 1149–1162. DOI: 10.1080/09500340408230413.

[5] *ill.eu*. Last accessed 23/09/2022. URL: https://www.ill.eu/.