The coherent scattering length of $^{86}$Kr determined by neutron interferometry

B.P. Terburg and P. Verkerk

Interfacultair Reactor Instituut, Technische Universiteit Delft, 2629 JB Delft, The Netherlands

E. Jericha and M. Zawisky

Atom Institut der Osterreichischen Universitaten, Schüttelstrasse 115, A-1020 Wien, Austria

Received 6 July 1992

We determined the coherent neutron scattering length of gaseous natural krypton and $^{86}$Kr using neutron interferometry. Measurements were performed at a 250 kW TRIGA reactor. The result for $^{86}$Kr, $b_c = 8.07(26)$ fm is new; the result for $^8$Kr is in excellent agreement with literature. The accuracy of the results is restricted by the stability of the setup and not by the limited neutron flux. The results obtained at the small reactor prove that neutron interferometry is feasible even at small neutron sources, provided that a stable setup is used.

1. Introduction

In recent years neutron interferometry proved to be a useful method to determine thermal neutron coherent scattering lengths of solids, liquids and gases. Early interferometry experiments on gaseous H$_2$, D$_2$, He, $^3$He, N$_2$, O$_2$, Ne, Ar, Kr, and Xe were performed by Kaiser and Rauch using the symmetric LLL-interferometer [1,2] at the Institut Laue-Langevin, Grenoble. We carried out measurements on the noble gases Ne, Kr, and $^{86}$Kr, using a skew symmetric interferometer at the TRIGA-reactor (steady power 250 kW, $\phi_{th} = 1.0 \times 10^{13}$ cm$^{-2}$ s$^{-1}$ [3]) of the Atom Institut der Österreichischen Universitaten in Vienna. At this reactor perfect crystal neutron interferometry was accomplished for the first time [4].

2. Samples

We used a $^{86}$Kr-sample provided by P.A. Egelstaff (University of Guelph, Ontario) and R. Robinson (Los Alamos Neutron Scattering Centre LANSCE). The amount was 27 l STP containing 99.74 mole % krypton of which 99.33% was $^{86}$Kr. This sample is intended for neutron scattering experiments, but until now the coherent scattering length of $^{86}$Kr was unknown. We also used a sample of natural krypton ($^8$Kr, 80 l STP, purity 99.99%), in order to check consistency with values for the coherent scattering length from literature. Natural neon (Ne, 12 l STP, purity 99.99%) was used for reference gas (see below). $^8$Kr and Ne were provided by the Atom Institut. All measurements took place at room temperature, which is well above the critical temperature of $^{8}$Kr ($T_{cr} = 209.40$ K) and Ne ($T_{cr} = 44.4$ K) so the samples were gaseous during the experiments. Particle densities $N$ are calculated using the equation of state by Rabinovich et al. [5].

3. Interferometric measuring method

In principle neutron interferometry determines the index of refraction $n$ which is related to the neutron-nucleus coherent scattering length $b_c$ (Rauch and Tuppinger [6]):

$$n = 1 - \frac{\lambda^2 N b_c}{2\pi},$$

(1)

with $\lambda$ the neutron wavelength and $N$ the particle number density. The skew symmetric interferometer [6] is an improved version of the conventional symmetric LLL-interferometer and has a mirror plate which is divided into two parts, providing a larger sample space. However, the sample space is still insufficient to place the sample container in the so called nondispersive position in which measurements are wavelength inde-