Poisson's spot with molecules

T. Reisinger[a,c], Amil A. Patel[b], H. Reingruber[c], K. Fladischer[a,c], W. E. Ernst[c], G. Bracco[a,d], H. I. Smith[b], and B. Holst[a,c]

[a]Department of physics and technology, University of Bergen, Allégaten 55, 5007 Bergen, Norway

[b]NanoStructures Laboratory, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA

[c]Institute of Experimental Physics, Graz University of Technology, Petersgasse 16, 8010 Graz, Austria

[d]Department of Physics and CNR-IMEM, University of Genova, V. Dodecaneso 33, 16146 Genova, Italy

treisinger@gmail.com

March 11^{th}, 2010

Abstract

In the Poisson-Spot experiment, waves emanating from a source are blocked by a circular obstacle. Due to their positive on-axis interference an image of the source (the Poisson spot) is observed within the geometrical shadow of the obstacle. At the beginning of the 19^{th} century the Poisson spot experiment played a crucial role in proving the wave-nature of light[1] and now it is the last of the classical optics experiments to be realized with neutral matter waves.

Here we report the observation of Poisson's Spot using a beam of neutral deuterium molecules (see fig.1). We used a supersonic-expansion beam from a nozzle cooled to a temperature of 101 K. This resulted in a terminal beam velocity of v=1060 ms^{-1}, as determined from time-of-flight spectra, and corresponding to a de Broglie wavelength of λ=0.096 nm. The circular obstacle was a free-standing silicon-nitride disk of 60 μm diameter. We detected the beam using an electron-bombardment ionization detector.

Interesting applications could include the study of large-molecule or cluster diffraction and coherence in atom-lasers. There are a few advantages over grating interferometers that could possibly outweigh the drawbacks from the low-brightness nature of the Poisson spot. One is that the interaction with the matter-wave beam is reduced to a single edge, transmitting even objects that would block a fine grating. Also, constraints on angular alignment and position of the circular obstacle are very weak. Furthermore, the on-axis interference condition for the Poisson Spot is wavelength independent and can therefore utilize the entire velocity and mass spectrum of potential beam sources.

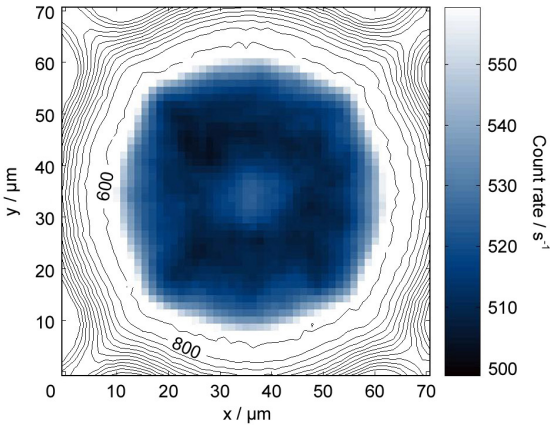

Figure 1: Deuterium matter-waves forming a Poisson spot.

Keywords: POISSON SPOT, DEUTERIUM, FREE-JET EXPANSION

References

[1] A.J. Fresnel, OEuvres completes 1, Imprimerie impériale, Paris (1868).