Babinet's principle in atom optics

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We investigate Babinet's principle in quantum reflection of helium atoms from diffraction gratings. Helium atom beams are reflected and diffracted by square-wave gratings at grazing incidence angles of a few milliradians. According to Babinet's principle the diffraction intensities are expected to be identical for a pair of complementary geometric gratings. We figure out both conditions where Babinet's principle fails and where it holds. Our data for the two complementary gratings reveal that the conditions for its breakdown are where either incident or diffracted beams propagate close to the grating surface. The breakdown of Babinet's principle is also prominent near Rayleigh conditions where a new spectral order emerges from the grating surface. At these conditions, the incident and diffracted helium beams are strongly affected by the dispersive interaction between the atoms and the grating surface. We therefore attribute the breakdown to atom-surface interactions and emerging beam resonances. Contrarily, the principle holds for the conditions where the effects of the atom-surface interaction and the emerging beam resonances are not significant.