Effect of atom-surface interaction on matter-wave diffraction from a periodic array of half planes

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We have recently shown that diffraction of matter-wave from a square-wave grating of 400-μm period and 10-μm wide strips results mainly from scattering off a periodic array of parallel half-planes. This phenomenon is understood as multiple diffractions of waves at those half-planes. Here we study how the interaction of the matter-wave with the grating surface of a finite width affects the half-plane array diffraction. The interaction induces an additional phase shift along the path of the matter-wave, and, therefore, reduces the diffraction efficiency. The interaction effects appear differently for He and D2, for gratings of different period with the same strip width, and for He atoms of different de Broglie wavelengths. Moreover, we demonstrate the reflection of fragile He3 from a square wave grating via the half-plane array diffraction. In the future, by designing a super-periodic half-plane array with a small half-plane period and a large grating super-period, it will be possible to study diffraction of fragile van der Waals clusters such as He2 and He3. The combination of half-plane array and super-period grating will lead to diffraction at enhanced reflection probabilities as compared to previous experiments.