Observation of Fermi-surface-deformations in ultracold polar molecules

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Ultracold dipolar molecules are a promising platform for exploring exotic quantum many-body phenomena thanks to their long-range dipole-dipole interaction. In a degenerated dipolar Fermi gas, the competition between kinetic and interaction energy can modify the momentum space distribution, leading to Fermi-surface-deformations (FSD) [1, 2, 3]. Here, we report on the first observation and systematic study of these deformations in ultracold polar molecules.

To create a stable, low-temperature dipolar molecular Fermi gas of $^{23}Na^{40}K$, we employ a dual-color microwave (MW) shielding scheme [4], reaching inelastic loss rates as low as 2×10^{13} cm s^{-1} at 400 nK. This is almost 3 times lower compared to our previous record using only circularly polarized MW and enables us routinely create deeply degenerate gases at 0.25 T/T_F. Using the two MW fields gives us full control over the dipolar interaction. Both its strength and direction are now tunable via the ellipticity of the circularly-polarized and relative Rabi frequency of the linearly-polarized MW field, giving rise to FSD of varying direction and magnitude. This work constitutes a starting point for further investigation into Fermi gases with tunable anisotropic dipolar interactions.

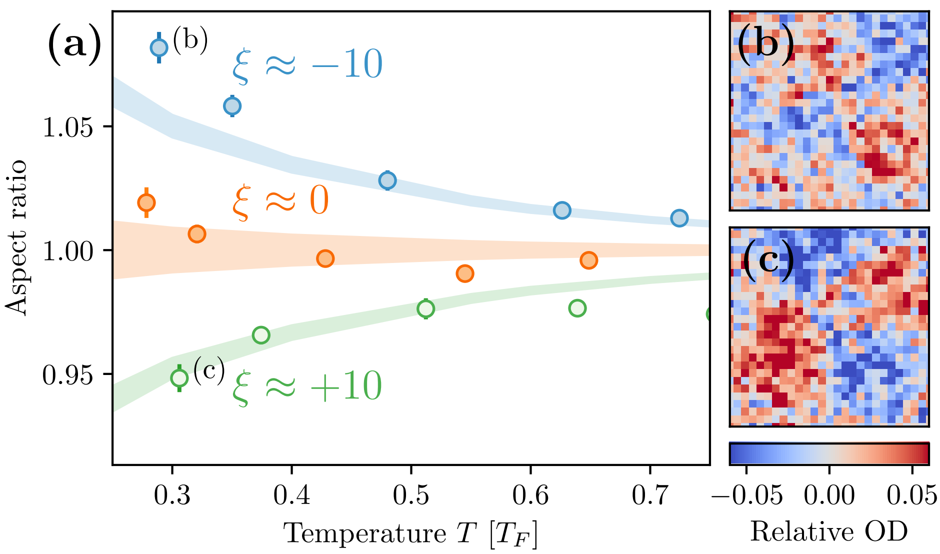

Figure 1: **(a)** Aspect ratio for three selected ellipticities ξ of the circularly polarized MW field at different temperatures. Obtained from Fermi-Dirac fit to absorption images after 14 ms time-of-flight (TOF). Bands show theory predictions for $\sqrt{\langle k_x^2\rangle/\langle k_y^2\rangle}$ by Wei Zhang. **(b)**, **(c)** Images obtained by subtracting TOF image rotated by 90° from original image $\xi \approx -10$ **(b)** and $\xi \approx +10$ **(c)** to reveal elliptical shape of the cloud. Orientation of the cloud follows the orientation of interaction, which is different by roughly 90° degrees between the two cases.

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References

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