Towards continuous-sources for magneto-optical trapping of AlF molecules

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Aluminum monofluoride (AlF) is an attractive molecule for laser cooling and trapping due to its deeply bound (6.9 eV) $X^1\Sigma^+$ electronic ground state, and its vibrationally diagonal $A^1\Pi \leftarrow X^1\Sigma^+$ laser cooling transition, whose entire Q(J) branch is rotationally closed. Following our recent demonstration of a magneto-optical trap (MOT) of AlF using a pulsed buffer gas cooled molecular beam [1], we aim to explore the continuous loading from alternative molecular sources.

We compare four source types: a high-temperature thermochemical oven, a cryogenic buffer-gas-cooled beam, a pulsed supersonic expansion, and a compact dispenser. The thermochemical oven produces a large total flux of molecules, with population spread over a few hundred rovibrational levels of the $X^1\Sigma^+$ state. The continuous output begins to exceed the peak brightness of a pulsed, jet cooled supersonic beam of AlF around the J=7 level. Buffer gas cooling with Ne reduces the peak forward velocity from 700m/s to 300m/s, and cools the internal temperature to around 30 K. Additionally, we implement a compact dispenser molecular beam that thermalizes with the room temperature walls to produce transient thermal vapour without requiring cryogenics or high power. Spectroscopy shows the molecules thermalize near 300 K, and a significant fraction of the velocity distribution lies within the MOT capture range.

This dispenser offers a low-cost, cryogen-free path toward continuously loaded molecular MOTs. We discuss the comparative advantages of each source and highlight the dispenser's potential for simple and scalable cold molecule experiments.

References

[1] Padilla-Castillo *et al.*, *Magneto-optical trapping of aluminum monofluoride*, arXiv:2506.02266.