Narrowline laser cooling of YO and

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Laser cooling of diatomic molecules [1, 2] is usually constrained by using a P(1) transition between an electronic Σ ground state and an excited state with Σ or Π character. I will present our recent work on narrowline laser cooling using transitions between the $X\,^2\Sigma^+$ ground electronic state and the metastable $A'\,^2\Delta_{3/2}$ of yttrium monoxide. We identified a quasi-closed photon-cycling scheme addressing a single quantum state. By applying small electric fields we isolated the desired pure-parity state energetically from unwanted mixed-parity states. With this additional quantum control we regained the required photon-cycling closure and achieved the first experimental realization of narrowline laser cooling on a molecule [3]. I will further discuss the potential of this metastable $^2\Delta$ state for future experiments and report on our ongoing efforts to realize a collisional stable gas of ultracold molecules in an optical dipole trap using the technique of microwave shielding.

References

[1] S. Ding, Y. Wu, I. A. Finneran, J. J. Burau, and J. Ye, *Physical Review X* **10** 021049 (2020)

[2] J. J. Burau, K. Mehling, M. D. Frye, M. Chen, P. Aggarwal, J. M. Hutson and J. Ye, *Physical Review A* **110** L041306 (2024)

[3] K. Mehling, J. J. Burau, L. E. Hillberry, M. Chen, P. Aggarwal, L. Cheng, J. Ye and S. Scheidegger, *arXiv* 2503.13838 (2025)