

# Laser spectroscopy of phonons and rotons in superfluid helium doped with Dy atoms

Kazan Federal University, 420008, Kremlevskaya 18, Kazan, Russia

---

## Abstract

© 2018 American Physical Society. We report the results of a high-resolution laser-spectroscopy study of dysprosium atoms injected into superfluid He4. A special attention is paid to the transitions between the inner 4f and 5d electronic shells of Dy. The characteristic gap is observed between the zero-phonon line and the phonon wing in the experimental excitation spectrum that arises due to the peculiar structure of the phonon-roton spectrum of superfluid He. This observation resolves the longstanding discrepancy between the studies of bulk superfluid He and He nanodroplets.

<http://dx.doi.org/10.1103/PhysRevB.97.094504>

---

## References

- [1] P. Moroshkin, A. Hofer, and A. Weis, Phys. Rep. 459, 1 (2008). PRPLCM 0370-1573 10.1016/j.physrep.2008.06.004
- [2] K. Ishikawa, A. Hatakeyama, K. Gosyono-o, S. Wada, Y. Takahashi, and T. Yabuzaki, Phys. Rev. B 56, 780 (1997). PRBMDO 0163-1829 10.1103/PhysRevB.56.780
- [3] Q. Hui and M. Takami, J. Low Temp. Phys. 119, 393 (2000). JLTPAC 0022-2291 10.1023/A:1004626121451
- [4] P. Moroshkin, V. Lebedev, and A. Weis, Europhys. Lett. 96, 26002 (2011). EULEEJ 0295-5075 10.1209/0295-5075/96/26002
- [5] P. Moroshkin, V. Lebedev, and A. Weis, J. Chem. Phys. 139, 104307 (2013). JCPSA6 0021-9606 10.1063/1.4820398
- [6] D. Hsu and J. L. Skinner, J. Chem. Phys. 81, 1604 (1984). JCPSA6 0021-9606 10.1063/1.447874
- [7] J. P. Toennies and A. F. Vilesov, Angew. Chem. Int. Ed. 43, 2622 (2004). 1433-7851 10.1002/anie.200300611
- [8] C. Callegari and W. E. Ernst, in Handbook of High-Resolution Spectroscopy, edited by M. Quack and F. Merkt (Wiley, New York, 2011), Vol. 3, pp. 1551-1594.
- [9] M. Hartmann, F. Mielke, J. P. Toennies, A. F. Vilesov, and G. Benedek, Phys. Rev. Lett. 76, 4560 (1996). PRLTAO 0031-9007 10.1103/PhysRevLett.76.4560
- [10] P. Moroshkin, V. Lebedev, and A. Weis, Phys. Rev. A 84, 052519 (2011). PLRAAN 1050-2947 10.1103/PhysRevA.84.052519
- [11] P. Moroshkin, V. Lebedev, and A. Weis, J. Low Temp. Phys. 162, 710 (2011). JLTPAC 0022-2291 10.1007/s10909-010-0304-2
- [12] M. Lemeshko, N. Y. Yao, A. V. Gorshkov, H. Weimer, S. D. Bennett, T. Momose, and S. Gopalakrishnan, Phys. Rev. B 88, 014426 (2013). PRBMDO 1098-0121 10.1103/PhysRevB.88.014426
- [13] M. Lu, N. Q. Burdick, S. H. Youn, and B. L. Lev, Phys. Rev. Lett. 107, 190401 (2011). PRLTAO 0031-9007 10.1103/PhysRevLett.107.190401
- [14] H. Kadau, M. Schmitt, M. Wenzel, C. Wink, T. Maier, I. Ferrier-Barbut, and T. Pfau, Nature (London) 530, 194 (2016). NATUAS 0028-0836 10.1038/nature16485
- [15] R. J. Donnelly and C. F. Barenghi, J. Phys. Chem. Ref. Data 27, 1217 (1998). JPCRBUR 0047-2689 10.1063/1.556028

- [16] T. Kinoshita, K. Fukuda, Y. Takahashi, and T. Yabuzaki, *Phys. Rev. A* 52, 2707 (1995). PLRAAN 1050-2947 10.1103/PhysRevA.52.2707
- [17] A. A. Buchachenko, G. Chalasinski, and M. M. Szczesniak, *Eur. Phys. J. D* 45, 147 (2007). EPJDF6 1434-6060 10.1140/epjd/e2006-00263-3
- [18] A. D. B. Woods and R. A. Cowley, *Rep. Prog. Phys.* 36, 1135 (1973). RPPHAG 0034-4885 10.1088/0034-4885/36/9/002
- [19] M. R. Gibbs, K. H. Andersen, W. G. Stirling, and H. Schober, *J. Phys. Cond. Matt.* 11, 603 (1999). JCOMEL 0953-8984 10.1088/0953-8984/11/3/003
- [20] P. Moroshkin and K. Kono, *Phys. Rev. A* 93, 052510 (2016). 2469-9926 10.1103/PhysRevA.93.052510
- [21] A. Kramida, Yu. Ralchenko, J. Reader, and NIST ASD Team, NIST Atomic Spectra Database (ver. 5.3), [Online]. <http://physics.nist.gov/asd> [2017, February 27]. National Institute of Standards and Technology, Gaithersburg, 2015.
- [22] M. Hartmann, A. Lindinger, J. P. Toennies, and A. F. Vilesov, *Phys. Chem. Chem. Phys.* 4, 4839 (2002). PPCPFQ 1463-9076 10.1039/B203249j
- [23] R. Lehnig and A. Slenczka, *J. Chem. Phys.* 122, 244317 (2005). JCPSA6 0021-9606 10.1063/1.1946739
- [24] W. Demtröder, *Laser Spectroscopy* (Springer, Berlin, 2008).
- [25] V. A. Komarovskii, *Opt. Spectrosc.* 71, 322 (1991)
- [26] V. A. Komarovskii, [*Opt. Spektrosk.* 71, 559 (1991)].
- [27] W. Guo, S. B. Cahn, J. A. Nikkel, W. F. Vinen, and D. N. McKinsey, *Phys. Rev. Lett.* 105, 045301 (2010). PRLTAO 0031-9007 10.1103/PhysRevLett.105.045301