

Cornish, S. L.; Parker, N. G.; Martin, A. M.; Judd, T. E.; Scott, R. G.; Fromhold, T. M.; Adams, C. S.

Quantum reflection of bright matter-wave solitons. (English) Zbl 1167.82322
Physica D 238, No. 15, 1299-1305 (2009).

Summary: We propose the use of bright matter-wave solitons formed from Bose-Einstein condensates with attractive interactions to probe and study quantum reflection from a solid surface at normal incidence. We demonstrate that the presence of attractive interatomic interactions leads to a number of advantages for the study of quantum reflection. The absence of dispersion as the soliton propagates allows precise control of the velocity normal to the surface and for much lower velocities to be achieved. Numerical modelling shows that the robust, self-trapped nature of bright solitons leads to a clean reflection from the surface, limiting the disruption of the density profile and permitting accurate measurements of the reflection probability.

MSC:

82C10 Quantum dynamics and nonequilibrium statistical mechanics (general) Cited in 4 Documents
35Q55 NLS equations (nonlinear Schrödinger equations)
35Q51 Soliton equations

Keywords:

quantum reflection; soliton; Bose-Einstein condensate

Full Text: [DOI](#) [arXiv Link](#)

References:

- [1] Dauxios, T.; Peyrard, M., *Physics of solitons*, (2006), Cambridge University Press
- [2] Dalfovo, F.; Giorgini, S.; Pitaevski, L.P.; Stringari, S., *Rev. modern phys.*, 71, 463, (1999), See, for example
- [3] Burger, S., *Phys. rev. lett.*, 83, 5198, (1999)
- [4] Denschlag, J., *Science*, 287, 97, (2000)
- [5] Khaykovich, L.; Schreck, F.; Ferrari, G.; Bourdel, T.; Cubizolles, J.; Carr, L.D.; Castin, Y.; Salomon, C., *Science*, 296, 1290, (2002)
- [6] Strecker, K.E.; Partridge, G.B.; Truscott, A.G.; Hulet, R.G., *Nature*, 417, 150, (2002)
- [7] Cornish, S.L.; Thompson, S.T.; Wieman, C.E., *Phys. rev. lett.*, 96, 170401, (2006)
- [8] Eiermann, B., *Phys. rev. lett.*, 92, 230401, (2004), In addition, gap bright solitons have been created using ^87Rb condensates confined in an optical lattice,
- [9] A.D. Cronin, J. Schmiedmayer, D.E. Pritchard, [arXiv:0712.3703v1](#)
- [10] Anderson, A.; Haroche, S.; Hinds, E.A.; Jhe, W.; Meschede, D.; Moi, L., *Phys. rev. A*, 34, 3513, (1986)
- [11] Shimizu, F., *Phys. rev. lett.*, 86, 987, (2001)
- [12] Pasquini, T.A.; Shin, Y.; Sanner, C.; Saba, M.; Schirotzek, A.; Pritchard, D.E.; Ketterle, W., *Phys. rev. lett.*, 93, 223201, (2004)
- [13] Pasquini, T.A.; Saba, M.; Jo, G.; Shin, Y.; Ketterle, W.; Pritchard, D.E.; Savas, T.A.; Mulders, N., *Phys. rev. lett.*, 97, 093201, (2006)
- [14] Lee, C.; Brand, J., *Europhys. lett.*, 73, 321, (2006)
- [15] Jurisch, A.; Rost, J.-M., *Phys. rev. A*, 77, 043603, (2008)
- [16] Adams, C.S.; Lee, H.J.; Davidson, N.; Kasevich, M.; Chu, S., *Phys. rev. lett.*, 74, 3577, (1995)
- [17] Grimm, R.; Weidemüller, M.; Ovchinnikov, Yu.B., *Adv. at. mol. opt. phys.*, 42, 95, (2000)
- [18] Cornish, S.L.; Claussen, N.R.; Roberts, J.L.; Cornell, E.A.; Wieman, C.E., *Phys. rev. lett.*, 85, 1795, (2000)
- [19] Feshbach, H.; Stwalley, W.C.; Tiesinga, E.; Verhaar, B.J.; Stoof, H.T.C., *Ann. phys. (N.Y.)*, *Phys. rev. lett.*, *Phys. rev. A*, 47, 4114, (1993)
- [20] Ruprecht, P.A.; Holland, M.J.; Burnett, K.; Edwards, M., *Phys. rev. A*, 51, 4704, (1995)
- [21] Bradley, C.C.; Sackett, C.A.; Tollett, J.J.; Hulet, R.G.; Bradley, C.C.; Sackett, C.A.; Hulet, R.G., *Phys. rev. lett.*, *Phys. rev.*

- lett., 78, 985, (1997)
- [22] Roberts, J.L.; Claussen, N.R.; Cornish, S.L.; Donley, E.A.; Cornell, E.A.; Wieman, C.E., *Phys. rev. lett.*, 86, 4211, (2001)
 - [23] Donley, E.A.; Claussen, N.R.; Cornish, S.L.; Roberts, J.L.; Cornell, E.A.; Wieman, C.E., *Nature*, 412, 295, (2001)
 - [24] Lenard-Jones, J.E., *Trans. Faraday soc.*, 28, 333, (1932)
 - [25] Casimir, H.B.G.; Polder, D., *Phys. rev.*, 73, 360, (1948)
 - [26] Mody, A.; Haggerty, M.; Doyle, J.M.; Heller, E.J., *Phys. rev. B*, 64, 085418, (2001)
 - [27] Friedrich, H.; Jacoby, G.; Meister, C.G., *Phys. rev. A*, 65, 032902, (2002)
 - [28] Nayak, V.U.; Edwards, D.O.; Masuhara, N., *Phys. rev. lett.*, 50, 990, (1983)
 - [29] Berkhout, J.J.; Luiten, O.J.; Setija, I.D.; Hijmans, T.W.; Mizusaki, T.; Walraven, J.T.M., *Phys. rev. lett.*, 63, 1689, (1989)
 - [30] Doyle, J.M.; Sandberg, J.C.; Yu, I.A.; Cesar, C.L.; Kleppner, D.; Greytak, T.J., *Phys. rev. lett.*, 67, 603, (1991)
 - [31] Yu, I.A.; Doyle, J.M.; Sandberg, J.C.; Cesar, C.L.; Kleppner, D.; Greytak, T.J., *Phys. rev. lett.*, 71, 1589, (1993)
 - [32] Scott, R.G.; Martin, A.M.; Fromhold, T.M.; Sheard, F.W., *Phys. rev. lett.*, 95, 073201, (2005)
 - [33] Scott, R.G.; Hutchinson, D.A.W.; Gardiner, C.W., *Phys. rev. A*, 74, 053605, (2006)
 - [34] Landragin, A.; Courtois, J.-Y.; Labeyrie, G.; Vansteenkiste, N.; Westbrook, C.I.; Aspect, A., *Phys. rev. lett.*, 77, 1464, (1996)
 - [35] Côté, R.; Segev, B., *Phys. rev. A*, 67, 041604(R), (2003)
 - [36] Martin, A.D.; Adams, C.S.; Gardiner, S.A., *Phys. rev. lett.*, *Phys. rev. A*, 77, 013620, (2008)
 - [37] Aceves, A.B.; Molonnet, J.v.; Newell, A.C., *Phys. rev. A*, 39, 1809, (1989)
 - [38] Parker, N.G.; Cornish, S.L.; Adams, C.S.; Martin, A.M., *J. phys. B*, 40, 3127, (2007)
 - [39] Parker, N.G.; Martin, A.M.; Cornish, S.L.; Adams, C.S., *J. phys. B*, 41, 045303, (2008)
 - [40] Minguzzi, A., *Phys. rep.*, 395, 223, (2004)
 - [41] Parker, N.; Martin, A.M.; Adams, C.S.; Cornish, S.L., *Physica D*, 238, 1456, (2009), (this issue)
 - [42] Parker, N.G.; Proukakis, N.P.; Leadbeater, M.; Adams, C.S.; Proukakis, N.P.; Parker, N.G.; Frantzeskakis, D.J.; Adams, C.S., *J. phys. B*, *J. opt. B*, 6, S380-S391, (2004)
 - [43] Günther, A.; Kraft, S.; Kemmler, M.; Koelle, D.; Kleiner, R.; Zimmermann, C.; Fortágh, J.; Günther, A.; Kraft, S.; Zimmermann, C.; Fortágh, J., *Phys. rev. lett.*, *Phys. rev. lett.*, 98, 140403, (2007), This forced the BEC to rise up the far side of the harmonic trap and hence decelerate before striking the surface. This improves control of the impact speed, but the presence of the harmonic potential remains a complicating factor and can affect the condensate's dynamics
 - [44] Dimopoulos, S.; Geraci, A., *Phys. rev. D*, 68, 124021, (2003)

This reference list is based on information provided by the publisher or from digital mathematics libraries. Its items are heuristically matched to zbMATH identifiers and may contain data conversion errors. It attempts to reflect the references listed in the original paper as accurately as possible without claiming the completeness or perfect precision of the matching.