Appendix A

Numerical TOP trap model

What follows is a brief outline of the numerical TOP trap simulator that has been passed down through the generations. In this code the condensate position is found from locating a minimum in the combined magnetic plus gravitational potential. Trap frequencies are then determined from the second derivative of this potential at the condensate position. For this model we define the total potential as.

$$E_{potential} = E_{Breit-Rabi} + mgz \tag{A.1}$$

Here m is the mass of ^{87}Rb, g is 9.8 m/s^2 and z is the displacement from the quadrupole center. $E_{Breit-Rabi}$ is an augmented form of equation 3.7 of Heather Lewandowski's Thesis [105][1] .

$$E_{Breit-Rabi} = -\frac{h\nu_{hs}}{8} - g_I \mu_{bohr} B m_F \pm h\nu_{hs}\sqrt{1 + m_F x(B) + x^2(B)} \tag{A.2}$$

$$x(B) = (g_J + g_I)\frac{\mu_{bohr}}{h\nu_{hs}} B \tag{A.3}$$

Here ν_{hs} is hyperfine splitting for ^{87}Rb and h is planks constant. F and m_F refer to the magnetic state of the atom being trapped (F=1 and $m_F = -1$ for the purpose of

[1] Note that this is not the same as equations 3.2 and 3.3 of Matthews [59] which appears to contain a typo

this thesis), and B is the magnitude of the instantaneous magnetic field. Using the full Breit-Rabi equation is clearly over kill for the application described in §2.3, but the generality of this method is useful in calculating two-photon transition frequencies [59] not discussed in this thesis. The magnetic field, B, can be broken into two key parts: the magnitude of the bias field B_0, and the gradient to the quadrupole field along the z axis B'_q. In these terms B can be written

$$B = \sqrt{(\frac{B'_q}{2}x + B_0\xi_1 sin(2\pi\nu t))^2 + (\frac{B'_q}{2}y + B_0\sqrt{1-\xi_1^2}cos(2\pi\nu t))^2 + (B'_q z + (-1)^{(f+1)}\frac{2h\nu}{\mu_{bohr}})^2}. \tag{A.4}$$

This is a slightly more concise form of equation 3.16 from Matthews [59]. Note that the $2h\nu/\mu_{bohr}$ term is an effective field that arises from the inability of the atom spin to adiabatically track the rotating bias field, otherwise known as the wierd Bohn effect (see [59]). The TOP frequency, ν, is 1800 Hz for the purpose of this thesis. The parameter is ξ_1 inserted to model the effect of the distorted bias field. Using the notation from §2.2 the distortion of the rotating bias field has the form

$$\varepsilon = \frac{1 - \xi_1/\sqrt{1-\xi_1^2}}{1 + \xi_1/\sqrt{1-\xi_1^2}}. \tag{A.5}$$

Table A.1: Table of useful constants, largely from Lewandowski [105]

constant	value	unit
μ_{bohr}	$9.27400899(37) \times 10^{-28}$	J/G
ν_{hs}	6834.68261090434(3)	MHz
g_J	2.00233113(20)	
g_I	$.9951414(10) \times 10^{-3}$	

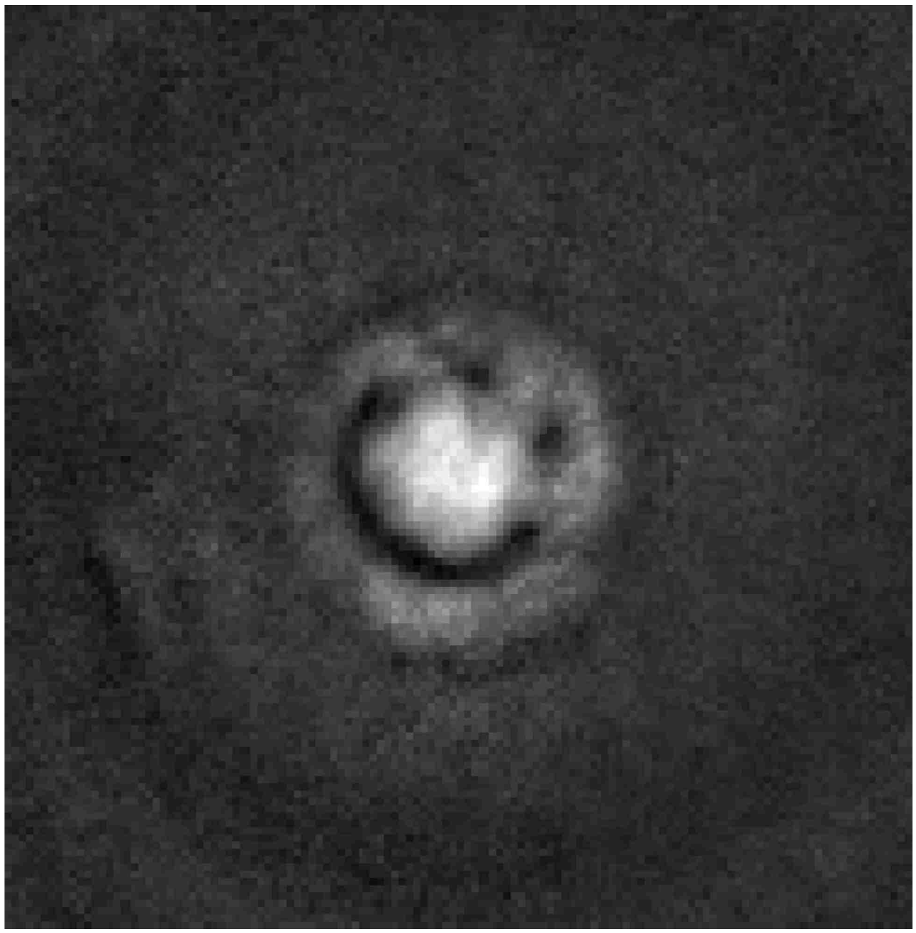

Figure A.1: