Chapter 5

Conclusion and Future

There are several new techniques now that should allow for a more precise determination of the electron or positron anomalous magnetic moment. First, the capability to measure the damping constant as a function of detuning from a cavity mode should allow the precise knowledge and control of the radiation environment of the particle [45], and thus the elimination of the leading systematic uncertainty in the latest g-2 measurement. The cyclotron damping rate should be explicitly measured as a function of detuning from a known cavity mode. Second, the use of the relativistic bottle and parametric dark detection to measure the cyclotron frequency to 1 ppb provides a method that avoids inhomogeneous magnetic field broadening and detector noise disturbances. This was made possible by the development of an extremely low phase noise microwave source. Specific attention should be made to the various external magnetic bottles [39, 68, 10, 9]. The possibility of almost completely cancelling the relativistic bottle should be tried [39]. Furthermore, the new self-shielding solenoid [44] should provide a more stable magnetic field which is crucial for a precise cyclotron frequency determination. Thus, a more precise g factor measurement should now be possible.

The study of the parametric oscillations [92] of the electron have suggested several areas of investigation. The important characteristic that allows for the use of these parametric properties is a small anharmonicity coefficient, C_6 [35]. Perhaps a new trap could be designed with this in mind. The sign of the coefficient should be chosen with the particular overall detection bottle direction in mind. The parametric risetimes need to be studied more closely to see if it is possible to stabilize the system enough so as to demonstrate a much longer risetime near the edges of the excitation bands. Perhaps a higher Q detection tuned circuit (which would give a larger damping width) would be necessary. These risetime studies would be useful in measuring the temperature of a particle. Two schemes for further reducing the temperature of the particle are a direct refrigeration and a cavity sideband cooling technique [37]. The self-excitation scheme needs to be studied more both theoretically and experimentally. Better filters and amplifiers, as well as a phase shifter should be used. The direct resonant feedback as well as the frequency doubled feedback scheme should then be studied. It would be of great interest for metrology to observe a self-excited oscillator whose frequency would respond to specific condition changes [27]. Preliminary calculations suggest that it is possible to construct a stable parametric feedback loop which has a frequency that follows these specific condition changes. Finally, the parametric excitation of the cyclotron motion should be investigated, either by doubling the microwave source frequency, or more likely by reducing the magnetic field to a half. This should show interesting characteristics, and possibly squeezing [23]. Dark detection with the parametrically excited cyclotron motion may have advantages of stability and squeezed noise. Now that the parametric electron oscillator has been studied carefully, these several new techniques with different parametric subsystems should be pursued.

The two particle behavior, specifically the breathing mode motion, should be theoretically modelled [5, 4, 52]. Initial work has been done on modelling the two proton system. The two particle study is the first step toward understanding many particle plasma behavior.