a technique with which charged particles with a specific charge-to-mass ratio e/m can be confined in all three dimensions.

To detect the ions, a resonance detection technique is used, taking advantage of the fact that for given parameters of the trap each charge-to-mass ratio exhibits a unique "eigen frequency". In addition to the radio-frequency quadrupole field an RF dipole field at the frequency ω_{RES} is applied to the end caps. If through proper choice of the parameters a and q (representing the amplitudes of the rf component and the dc component of the quadrupole field) the ions are brought to resonance with this dipole field the amplitude of the ion motion is increased, absorbing energy from the drive field, which can be detected. The important fact was, that different ions will have different frequencies for a given set of a and q, or, that at a fixed frequency one can bring all different ion species to resonance subsequently by slowly varying the DC potential at a constant RF amplitude. This made the quadrupole trap an ideal tool for precision mass spectrometry or residual gas analysis, areas in which RF traps have gained high respect over the last decades.

At first glance, the RF drive field seems to be a disturbance to the system, and in effect it is. Due to the continuously applied drive force stored particles are heated permanently, leading to 2nd order doppler broadening of spectral lines. This effect can be counter acted by cooling mechanisms, either collisions with residual gas molecules, or far more powerful and selective than this, by laser cooling. Nevertheless, due to this "micro motion" the Paul trap has always been a second choice to the Penning trap if the proposal was for ultra high precision work. Recent advances have been made in this direction by using "linear" [7] or "circular" [8,9] traps, in which a zero RF amplitude can be sustained over an extended region in space, allowing laser cooling of ions to the photon recoil limit. This opens up areas which were traditionally reserved for Penning traps and the advantage of not having to supply a strong, highly homogeneous, magnetic field can be finally utilized.

3.2 The Penning Trap.

The fundamental idea of the Penning trap dates back to the late 1930's when F. M. Penning published his work on increasing the sensitivity of ionization vacuum gauges by using an axial magnetic field. He observes, that 'with a magnetic field of sufficient strength, electrons, leaving the cathode, will miss the anode and return to the cathode - thereby reducing the anode current to zero, when the magnetic field is increased beyond a certain value.' He then continues to describe the effect, that '....if