Chapter 8

Summary and Outlook

We have considered, in this thesis, an atom surrounded by an arbitrary electric charge distribution. The Coulomb potential to which the atom is exposed is analysed into its 2'-pole components. It is well known that the dipole field leads to linear Stark effect in atoms like hydrogen, when opposite parity states are degenerate in energy. In the case of atomic energy states with $J \geq 1$, which are good eigenstates of parity, we show that the quadrupole field produces characteristic level splittings which differ from that produced by external magnetic fields through the Zeeman effect, provided of course that the atom has a non-zero electric quadrupole moment. When transitions occur between atomic states in the environment of an electric quadrupole field, the resulting spectral lines have distinct polarization properties characterized by Stokes parameters $Q, U, V$, which differ from polarizations produced by Zeeman effect. The effects theoretically predicted in this thesis provide therefore an additional diagnostic
can be applied to discuss also the so-called forbidden lines, which have been observed in astrophysical situations. For example, the astrophysically important S II and O II lines at 733 nm and 407 nm.

For illustrative purposes, we have considered transitions between \( J = 1 \) and \( J = 0 \) levels and also between \( J = 3/2 \) and \( J = 1/2 \) levels as particular cases. The effects predicted theoretically in this thesis may be verified through controlled laboratory experiments. They also provide an additional diagnostic to the study of the presence of electric fields not only in astrophysics but also in physical environments like clouds. The theoretical study may also find an application in the context of traps, for example the Paul trap in the case of pure electric quadrupole field and the Penning trap in the case of combined electric quadrupole and magnetic fields (Hans Dehmelt 1990, Wolfgang Paul 1990, Norman F Ramsey 1990).