Classical physics seems completely incapable of explaining the stability of atoms. For example, every Hydrogen atom appears to absorb or radiate electromagnetic energy at frequencies given by Balmer's formula (1885)

$$\nu_{mn} = R\left(\frac{1}{m^2} - \frac{1}{n^2}\right). \qquad (1)$$

The implication is that the structure of the atom is largely unchanged by collisions with other atoms, and this seems incompatible with any classical model of the atom as a miniature solar system. Moreover, even if classical physics were able to explain the stability of atoms, it would not be able to predict the observed spectral frequencies.

The classical explanation for the emitted radiation is that any accelerating charged particle will emit radiation, and that the electron is accelerating as it orbits the nucleus. The difficulty is that the electron's position in its orbit would presumably be a periodic function of time, and so could be expanded in a Fourier series

$$x(t) = \sum_{\alpha=-\infty}^{\infty} x_\alpha e^{\alpha\omega t}. \qquad (2)$$

The spectral frequencies would then be read off from this series, with the result that the observed frequencies should be multiples of some fundamental frequency (integral linear combinations of fundamental frequencies in the multi-dimensional case). In mathematical terms, the classical prediction is that the spectral frequencies should form a free abelian group, Γ, and this is not what is observed. Rather, the experimental result is that for any given type of atom the spectral frequencies may be labelled with two indices in such a way that the Ritz-Rydberg combination principle holds: whenever ν_{mn} and ν_{np} are observed frequencies, so is their sum, and

$$\nu_{mn} + \nu_{np} = \nu_{mp}. \qquad (3)$$

(Note that the Balmer formula is an example of this principle.)