

Ultra Cold Plasma Source Program

Written by Administrator

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The Ultra Cold Plasma Source team has recently joined CXS. The team is currently focusing on the Ultra Cold Plasma project, a new initiative to develop and investigate strongly coupled plasma and frozen Rydberg gas, with direct application to the production of a new type of X-ray source.

Frozen Rydberg gas, and ultra cold plasma, are relatively new and esoteric forms of matter, with new puzzles, and new opportunities. To quote an editorial review in *Physics World* [1], "these exotic and relatively unexplored states of matter may... help us to understand the surfaces of neutron stars and the centres of planets such as Jupiter". It is an area of intense innovation, with frequent coverage in the most selective journals. Several experimental research groups are now working in the area, including collaborators at Technische Universiteit Eindhoven (Netherlands), but this project is the first Australian research programme. Some of the fundamental processes and interactions have been demonstrated, and inspiring achievements are published with increasing frequency, but there is great opportunity for innovation both in new concepts and in realising their potential.

The starting point for work in this area is a magneto optical trap (MOT), in which a cloud of about 10⁸ rubidium atoms are laser-cooled to micro-Kelvin temperatures and trapped in a region about 1 mm in diameter. The process has often been compared to "throwing ping-pong balls at a tank", but with lasers, it's an awful lot of ping pong balls!

Using another high power laser, the atoms can either be excited to very high energy states to form frozen Rydberg gas, or ionised just above the threshold, resulting in ultra cold plasma. Plasma (like that found in fluorescent light tubes) is usually weakly coupled, meaning that the electrostatic binding between the charged particles is weaker than the thermal energy, and indeed must be so since the plasma is usually formed by heating neutral atoms until they separate.

Strongly coupled plasma is found in peculiar astrophysical systems such as white dwarfs and

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neutron stars, where gravitational and magnetic forces dominate over thermal ionisation.

Ultra cold plasma can also be used to produce X-rays, by accelerating the cold electrons and scattering laser light off the resulting fast electron cloud. Since the electron cloud is cold, this type of electron source has the potential to provide a high brightness source for X-ray production.

Currently, Sebastian Saliba, PhD Student is working on modelling a rubidium atom source to load atoms into the MOT, while Dave Sheludko, PhD Student, has recently demonstrated a new imaging technique for cold atoms that will be used to optimise production of the plasma, and study Rydberg atoms. Simon Bell, PhD Student is currently collaborating with researchers in Eindhoven to develop the design of the MOT and vacuum chamber for the Australian research laboratory.

Other experiments in the lab include investigations into quantum squeezing, an atomic clock using electromagnetically induced transparency and 'slow light'.

[1] Bergeson S, Killian T, Physics world 16 37 (2003)