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Positron and Positronium interactions in atomic and molecular systems

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Antimatter remains one of the most intriguing frontiers in modern physics. The most readily available form of antimatter is the positron, the electron antiparticle, which can briefly bind with an electron to form positronium (Ps)—a short-lived, hydrogenic 'atom'. Positron and positronium can used to explore and test our understanding of scattering dynamics and fragmentation in antiparticle interactions with atomic and molecular systems.

These interactions are not only of fundamental interest but also underpin key technologies. Positron Emission Tomography (PET), for example, relies on an understanding of how positrons and positronium behave in biological media. Similarly, Positron Annihilation Spectroscopy (PAS) is used to probe structures in materials at the nanometre scale. Central to both is the formation, transport, and decay of positronium—particularly ortho-positronium, which can diffuse and interact before annihilation, affecting both image resolution and radiation dose models.

A striking feature of positronium is its tendency to scatter like a heavy electron. This raises the possibility that Ps could induce molecular damage through mechanisms similar to dissociative electron attachment (DEA), a known cause of DNA strand breaks. Yet, the fate of positronium after formation in complex biological environments remains poorly understood.

Even small atoms pose challenges when describing positron and positronium interactions in theoretical models. The treatment of positron-electron correlations and the formation of positronium in positron collisions with atoms requires innovative and complex theoretical approaches.

This talk will highlight some of our recent work on positron and positronium physics as well as indicate future plans for studies of spin-dependent interactions with cold, trapped Rb atoms where positronium formation will dominate, and Ps scattering from molecules to investigate DEA-like fragmentation of biological molecules. Hopefully these insights will inform applications in medical imaging, materials science, and fundamental antimatter research.

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