

# Microwave spectroscopy of positronium: progress and future prospects

D. B. Cassidy

Department of Physics and Astronomy, University College London, Gower Street, London, WC1E 6BT, United Kingdom

The leptonic positronium (Ps) atom is a well-established system with which to test QED theory and fundamental symmetries, and may even be used to test for new physics [1]. Such tests may be performed via spectroscopic means or by looking at various annihilation decay modes, some of which are forbidden by various discrete symmetries, such as charge conjugation, parity and spatial transformations (i.e., C, P and T) and combinations thereof, [2]. For many years the experimental precision of optical and microwave spectroscopic measurements of Ps energy levels has been much lower than the corresponding QED calculations, generally by an order of magnitude or more [1]. Recent work at UCL has been undertaken to address this imbalance by performing improved microwave spectroscopy of the PS  $n = 2$  fine structure [3]. Some advances have been made, which in turn have revealed some systematic effects that must be addressed before more progress can be made. In this talk I will give a summary of these measurements, and discuss how we plan to move forward to higher precision tests. I will also discuss some related work using Ps microwave methods, such as testing C symmetry [4] and measurements the spin polarization of a slow positron beam [5].

## References

- [1] Adkins, G., Cassidy, D. & Pérez-Ríos, J. Precision spectroscopy of positronium: Testing bound-state QED theory and the search for physics beyond the Standard Model *Physics Reports*. **975** 1 (2022).
- [2] Bernreuther, W., Low, U., Ma, J. & Nachtmann, O. How to Test CP, T and CPT Invariance in the Three Photon Decay of Polarized s Wave Triplet Positronium. *Z. Phys. C*. **41** 143 (1988)
- [3] Sheldon, R., Babij, T., Reeder, S., Hogan, S. & Cassidy, D. Precision Microwave Spectroscopy of the Positronium  $2^3S_1 \rightarrow 2^3P_2$  Interval *Phys. Rev. Lett.*. **131**, 043001 (2023).
- [4] Conti, R., Hatamian, S., Lapidus, L., Rich, A. & Skalsey, M. Search for C-violating, P-conserving interactions and observation of  $2^3S_1$  to  $2^1P_1$  transitions in positronium *Physics Letters A*. **177**, 43 (1993).
- [5] Newson, D. & Cassidy, D. Measurement of the Spin Polarization of a Slow Positron Beam Using Circularly Polarized Microwave Radiation *Phys. Rev. Lett.*. **133**, 233004 (2024).