

First Positronium and Quantum Entanglement Imaging of humans with J-PET

Thursday, 4 December 2025 09:15 (45 minutes)

Jagiellonian-PET (J-PET) is a novel, cost-effective positron emission tomography technology based on plastic scintillators [1,2]. The J-PET system constructed at the Jagiellonian University is the first multi-photon PET scanner [3] capable of measuring momentum vectors and the orientation of polarization planes of photons originating from positronium decays [4]. Positronium imaging is a newly invented method for imaging the properties of positronium in living organisms [5,6,7,8]. Quantum Entanglement Imaging is a method enabling the imaging the degree of the entanglement of annihilation photons [9].

We will present the first-ever images of the properties of positronium in humans [8], the first multi-photon images from the decays of positronium atoms into three photons [3], and the first observation of non-maximal entanglement of photons from positronium annihilation in matter [9]. We will discuss the status of the development of (i) positronium imaging and (ii) degree of quantum entanglement imaging as possible diagnostic biomarkers of tissue pathology [10] and biomarkers of hypoxia [11].

References

- [1] P. Moskal, E. Ł. Stępień, PET Clinics 15, 439 (2020).
- [2] P. Moskal et al., Phys. Med. Biol. 66, 175015 (2021).
- [3] P. Moskal et al., Nature Communication 12, 5658 (2021).
- [4] P. Moskal et al., Nature Communication 15, 79 (2024).
- [5] P. Moskal, Positronium Imaging, IEEE NSS MIC 2018, 10.1109/NSSMIC.2018.8824622
- [6] P. Moskal, E. Ł. Stępień et al., Nature Reviews Physics 1, 527 (2019).
- [7] P. Moskal et al., Science Advances 7, eabh4394 (2021).
- [8] P. Moskal, ···, E. Ł. Stępień, Science Advances 10, eadp2890 (2024).
- [9] P. Moskal et al., Science Advances 11, eads3046 (2025).
- [10] P. Moskal, ···, E. Ł. Stępień, EJNMMI Phys. 10, 22 (2023).
- [11] P. Moskal, E. Ł. Stępień, Bio-Algorithms and Med-Systems 17, 311 (2021).

Presenter: MOSKAL, Pawel

Session Classification: Exotic atoms: fundamental aspects, applications and advances in radiation detectors