

How quantum entanglement can help in theranostics?

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Quantum entanglement is a phenomenon that shows the every working at small scales which differs strongly from the laws governing our daily world. Reading out this quantum information has the potential to reveal unknown processes and connections and on the long term to provide doctors with quantum indicators. This contribution focuses on the entanglement of two and three gammas emitted from positronium atoms, which is a frequent process in human beings undergoing e.g. a PET-scan (PET=Positron Emission Tomography). Theory predicts these two or three photon events to be entangled, more precisely in very special types of entanglement [1,2]. With the cutting-edge technology developed by the J-PET collaboration at the Jagiellonian University the detection of entanglement at this high energy scales is -for the first time- in reach [3]. This talk will give an overview over the progress made. Particularly, novel software developments [4] are needed to tackle this involved problem.

[1] B.C. Hiesmayr and P. Moskal, *Sci Rep* 9, 8166 (2019).

[2] B.C. Hiesmayr and P. Moskal, *Sci Rep* 7, 15349 (2017).

[3] P. Moskal, N. Krawczyk, B. C. Hiesmayr, M. Bała, C. Curceanu, E. Czerwinski, K. Dulski, A. Gajos, M. Gorgol, R. Del Grande, B. Jasinska, K. Kacprzak, L. Kapłon, D. Kisielewska, K. Klimaszewski, G. Korcyl, P. Kowalski, T. Kozik, W. Krzemien, E. Kubicz, M. Mohammed, Sz. Niedźwiecki, M. Pałka, M. Pawlik-Niedźwiecka, L. Raczynski, J. Raj, Z. Rudy, S. Sharma, M. Silarski, Shivani, R. Y. Shopa, M. Skurzok, W. Wislicki, B. Zgardzinska, *Eur. Phys. J. C* 78, 970 (2018).

[4] W. Krzemień, A. Gajos, K. Kacprzak, K. Rakoczy and G. Korcyl, *SoftwareX* 11, 100487 (2020).

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