FAMU: studies of the energy dependent transfer rate $\Lambda_{\mu p \to \mu O}$

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on behalf of the FAMU collaboration

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The main goal of the FAMU experiment is the measurement of the hyperfine splitting (hfs) in the 1S state of muonic hydrogen $\Delta E_{hfs}(\mu^- p)1S$ [1, 2, 3].

By measuring the transition $\Delta E_{hfs}(\mu^- p)1S$ in μp with $\delta\lambda/\lambda < 10^{-5}$, the experiment will provide the Zemach radius of the proton r_Z with high precision, disentangling in this way among discordant theoretical values. The level of discrepancy between values of r_Z as extracted from normal and muonic hydrogen atoms will be quantified, a result important also for the not yet explained anomalies on the charge r_{ch} radius of the proton. The physical process behind this experiment is the following: p are formed in a mixture of hydrogen and a higher-Z gas. When absorbing a photon at resonance-energy $\Delta E_{hfs} \approx 0.182$ eV, in subsequent collisions with the surrounding H_2 molecules, the μp is quickly de-excited and and accelerated by $\sim 2/3$ of the excitation energy. The observable is the time distribution of the K-lines X-rays emitted from the μZ formed by muon transfer $(\mu p) + Z \to (\mu Z)^* + p$, a reaction whose rate depends on the μp kinetic energy. The maximal response, to the tuned laser wavelength, of the time distribution of X-ray from K-lines of the $(\mu Z)^*$ cascade indicate the resonance.

During the preparatory phase of the FAMU experiment, several measurements have been performed both to validate the methodology and to prepare the best configuration of target and detectors for the spectroscopic measurement [4, 5, 6]. We present here the crucial study of the energy dependence of the transfer rate from muonic hydrogen to oxygen ($\Lambda_{\mu p \to \mu O}$), precisely measured for the first time.

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