Open MSc intership position - AG Riboldi

The AG Riboldi from the chair of medical physics is offering an internship position (6 ECTS equivalent) for a master student. A duration of five weeks full time is foreseen, corresponding to 6 ECTS credits. At the end of the internship, a scientific report (20 to 30 pages) needs to be handed in, describing the research and the results of the work. The internship can be done as a single block (5 weeks, 5 days per week, 8h per day) or extended over the semester (e.g. two days per week for 12 weeks).

Background

Cancer treatment based on external radiation with protons aims at accurate tumor targeting with maximal sparing of critical structures and normal tissue, in order to reduce radiation-induced toxicity and increase conformity. It can by achieved by the local dose deposition (the so called Bragg peak) an ion beam (e.g. proton beam) offers, which is the major advantage of treating with protons instead of photons. However, the increase of precision (locality) requires higher accuracy, which promotes the use of image guidance (IG). Magnetic resonance imaging (MRI) has been a successful tool in radiation oncology thanks to its exquisite soft tissue contrast and radiation free properties. The strong magnetic field strengths required (1.5 T and higher) however, interact with the proton beam [1] and complicate the delivery. In addition, combining the heavy machinery necessary for both the magnetic field and proton beam generation is a challenging problem, only solved conceptually to date [2].

Conversely, MRI is feasible also at low field strengths, circumventing the aforementioned issues. It is commonly assumed that the ultra-low field (ULF) MRI regime applies when the magnetic field for signal detection is below 10 mT. The corresponding signal however, cannot be detected with the standard pick-up coils due to its significantly lower strength. In recent years optical magnetometry (OM) has gained considerable interest, enabling highly sensitive measurements of magnetic field strengths. We have recently proposed the use of OM measurements to detect the magnetic field generated by a proton beam, which can be correlated to the proton range [3]. Outside the potential application to IG, the realization of OM detection of ULF MRI or NMR (nuclear magnetic resonance) signals has already been investigated (see e.g. [4, 5, 6]).

Tasks & goals

Your main task will be to (i) support the development of the control software for the OM setup and (ii) design an experimental procedure for the experimental investigation of ULF MRI for IG. A schematic overview of the basic OM setup is given in Figure 1.

Requirements & Qualifications

- Highly motivated for experimental work
- Strong programming skills in e.g. LabVIEW, MATLAB
- Experience with lasers is advantageous but not necessary

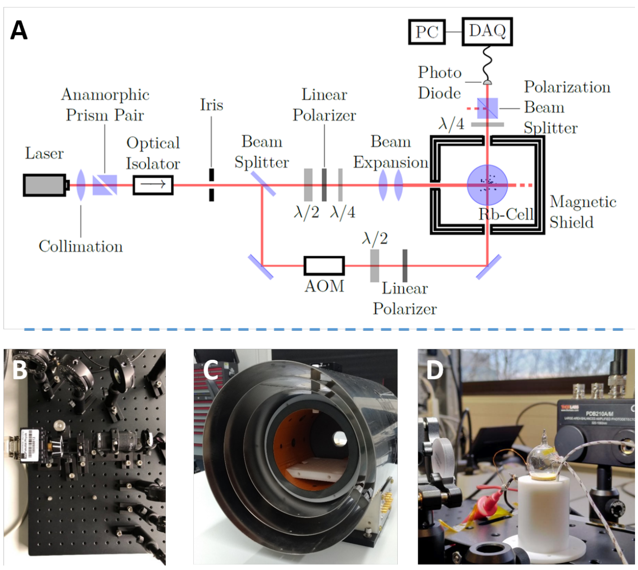

Figure 1: Optical magnetometry setup: A) schematic of the components, B) initial part of the laser beamline, C) magnetic shielding, D) vapor cell with heating system.

Contact

If you are interested, please contact (including a short CV, motivational letter and transcript of records)

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References

[1] Christopher Kurz et al. "A Monte-Carlo study to assess the effect of 1.5 T magnetic fields on the overall robustness of pencil-beam scanning proton radiotherapy plans for prostate cancer". In: *Physics in Medicine & Biology* 62.21 (2017), p. 8470.

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[3] Martin Rädler et al. "Electromagnetic Signal of a Proton Beam in Biological Tissues for a Potential Range-Verification Approach in Proton Therapy". In: *Phys. Rev. Applied* 15 (2 Feb. 2021), p. 024066. DOI: 10.1103/PhysRevApplied.15.024066. URL: https://link.aps.org/doi/10.1103/PhysRevApplied.15.024066.

[4] Shoujun Xu et al. "Magnetic resonance imaging with an optical atomic magnetometer". In: *Proceedings of the National Academy of Sciences* 103.34 (2006), pp. 12668–12671.

[5] IM Savukov and MV Romalis. "NMR detection with an atomic magnetometer". In: *Physical review letters* 94.12 (2005), p. 123001.

[6] Michael C. D. Tayler et al. "Instrumentation for nuclear magnetic resonance in zero and ultralow magnetic field". In: (2017). DOI: 10.1063/1.5003347. eprint: arXiv:1705.04489.