Open MSc position - AG Riboldi

The AG Riboldi from the chair of medical physics is offering a new master student position.

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. 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. [3, 4, 5]).

Tasks & goals

Your main task will be to support the construction and design of the OM setup to enable the experimental investigation of ULF MRI for IG. A schematic overview of the basic OM setup is given in Fig. 1. In addition, simulation work of the proton beam interaction with the irradiated substance (e.g. water/tissue) and the corresponding signal plus detection will be an integral part of the process.

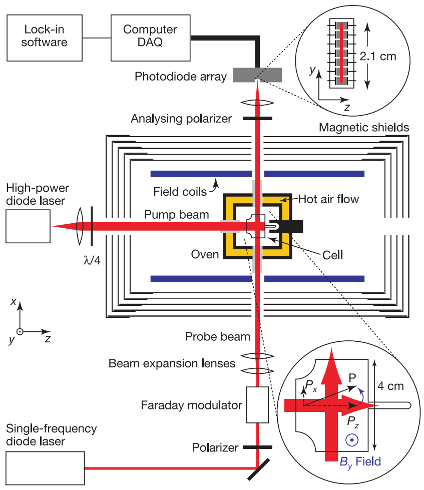

Figure 1: Optical magnetometry setup. (Figure adapted from [6].)

Requirements & Qualifications

- Highly motivated
- Strong academic record
- Basic programming skills in e.g. C++, MATLAB, Python
- Experience with laser spectroscopy is advantageous but not necessary

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.

[2] Bradley M Oborn et al. "Future of medical physics: Real-time MRI-guided proton therapy". In: *Medical physics* 44.8 (2017), e77–e90.

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

[5] 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.

[6] IK Kominis et al. "A subfemtotesla multichannel atomic magnetometer". In: *Nature* 422.6932 (2003), p. 596.