MPI meets MRI: A first MPI/MRI hybrid scanner

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Magnetic Particle Imaging (MPI) was firstly presented in 2005[1]. It is based on the nonlinear response of ferromagnetic material and the fact that the magnetization saturates at sufficiently high magnetic fields. For imaging a field free point (FFP) of a strong gradient on the order of 1-7 T/m is moved through the sample. Commonly, this gradient is generated by permanent magnets. Only from inside the FFP a MPI signal can be detected, otherwise the SPIOs saturate and the signal generation is suppressed[1]. In contrast to MRI, MPI directly detects the concentration and distribution of superparamagnetic iron-oxide nanoparticles (SPIOs) without any background of tissue. The first overlaid image, showing both imaging modalities, was published in 2009, but the datasets were acquired in separate scanners and a co-registration was required[2].

At first glance both modalities do not seem to match, because on the one hand the B_0 field of the MR system saturates the SPIOs and on the other hand the strong gradient of the MPI system disturbs the MRI. In this abstract a MPI/MRI hybrid scanner is presented, which use electrically switchable magnetic fields. For MRI a low-field-MRI (LFMRI) device was chosen[3,4] and for MPI the Traveling-Wave-MPI approach was used[4,5]. The advantage of combining both modalities in one device with the same receiver coil is that neither the sample has to be re-positioned nor any co-registration algorithm is required for overlaying the images.

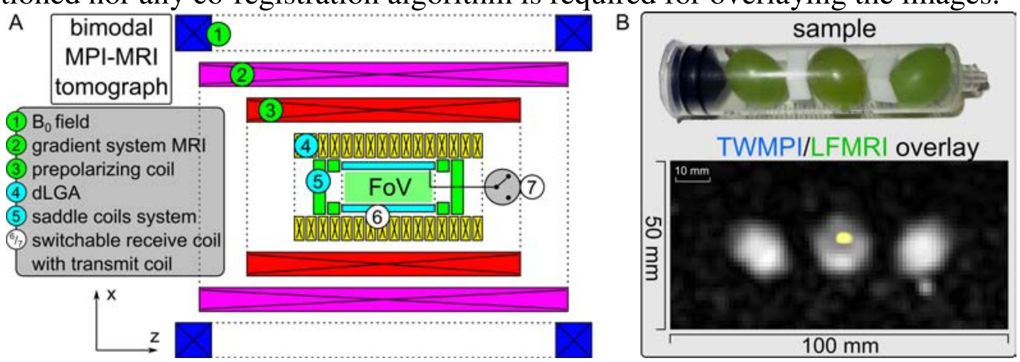

Fig. 1: **A**: sketch of the bimodal MPI/MRI scanner with switchable receiver coil (6/7). **B**: Three Bavarian grapes, where the second is prepared with undiluted Resovist®. The overlaid image shows exactly the position of the SPIOs.

The TWMPI device operates at an excitation frequency of about 16 kHz and generates MPI signal in the range up to 400 kHz. This frequency range matches perfectly with the resonance frequency of the LFMRI system for a B_0 field of about 1.1 mT (47.1 kHz for ^{1}H). A switchable prepolarizing coil (30 mT) is used to improve the LFMRI signal[7]. The TWMPI device works with an array of 20 individual drivable coil elements (dLGA), which create two FFPs traveling linearly along the symmetry axis using the traveling wave concept[6]. The two FFPs can be arbitrarily moved through the volume of interest with two perpendicular saddle coil systems.

Fig. 1 A shows a sketch of the MPI/MRI system: (1)-(3) are the B_0 field generator, the 3D gradient system and the prepolarizing unit of the LFMRI system. (4) and (5) are the dLGA and the two saddle coil systems. (6/7) represents the switchable receiver coil. Both experiments were performed successively without moving the sample. The second grape of the sample was prepared with undiluted Resovist® (Bayer Schering) (see fig. 1 B). The LFMRI image shows a signal extinction inside the second grape, where the overlaid TWMPI image shows exactly the position of the SPIOs. The acquisition time for the LFMRI projection was 11 min (8 averages) and 4.35 s for one TWMPI slice (4000 averages).

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