Appearant B_1^+ Asymmetry in Symmetric Objects at High Fields

Wyger Brink[1] and Andrew Webb[1]
[1]*Radiology, Leiden University Medical Center, Leiden, Zuid-Holland, Netherlands*

Target audience: Researchers working on neuroimaging at high field (>3 T).

Purpose: The complex interaction of the human body with the transmit RF field leads to distinct spatial patterns in the B_1^+ distribution, which have been well characterized for surface coils but not to the same extent when considering volume coils at high fields [1-3]. This work investigates, in particular, the origin of the distinct left-right asymmetry in the B_1^+ field typically observed in the head at 7 T.

Methods: In vivo B_1^+ maps were acquired using the DREAM method [4] at an in-plane resolution of 2.5 mm^2, on a Philips Achieva 7 Tesla system (Philips Healthcare, Best, The Netherlands) using a quadrature transmit/receive birdcage coil and a 32-channel receive array (Nova Medical, Wilmington, MA).

Simulations of the B_1^+ distribution in a model of the actual transmit coil were performed using xFDTD (Remcom inc., State College, PA, USA). The total configuration was simulated on a 2.5 mm uniform grid. All field data were normalized to 1 W of dissipated power.

An anatomically realistic head model 'Duke' was obtained from the Virtual Family dataset [5]. A simple phantom was then simulated, designed to approximate the geometrical features of the head model using a spheroid and a cylinder, as illustrated in figure 2. The phantom material properties were set to a relative permittivity of 45 and a conductivity of 0.5 S/m, similar to the average dielectric properties of the head model. Finally, a dielectric sphere was introduced to emulate the nasal cavity: the dielectric properties were then altered to show that the presence of this air-filled cavity in the head is the cause of the observed asymmetric B_1^+ distribution.

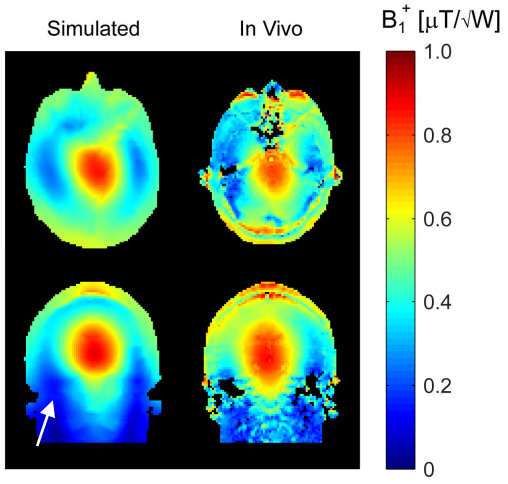

Figure 1. Simulated (left) and measured (right) B_1^+ distribution in the transverse (top) and sagittal (bottom) view.

Results: Figure 1 shows the simulated and measured B_1^+ distribution in the head. The measured data were scaled to correct for known losses in the RF chain. Figure 3 shows the B_1^+ distribution simulated in the phantom for different dielectric properties of the cavity. The drop in conductivity in the nasal cavity compared to surrounding tissue introduces a left-right asymmetry while the drop in permittivity reduces the B_1^+ intensity in the front of the brain. Taking both into account leads to the best representation of the B_1^+ pattern observed in the numerical head model and in vivo.

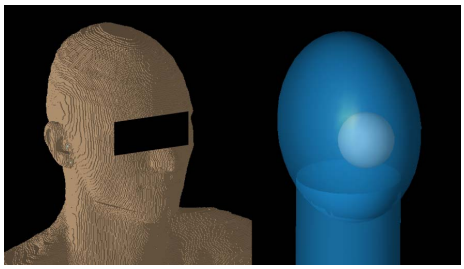

Figure 2. Simulated setup: numerical head (right) and phantom (right) model with a spherical perturbation illustrated in white.

Discussion: Although the transmit coil and human head can be assumed to be left-right symmetric, the B_1^+ field typically observed in vivo and in simulations features a left-right asymmetry, especially pronounced at the lower level of the brain (see arrow in figure 1). This effect has been observed to increase at higher field strengths as well [6].

The results presented in this work indicate that the left-right asymmetry in the B_1^+ distribution is linked to a front-back asymmetry in the phantom configuration, and also therefore in vivo, namely the nasal cavity. The effect has been shown to be related to the dielectric contrast in both the permittivity and conductivity of the nasal cavity. The left-right asymmetry was also observed in the vector magnitude of the B-field, meaning that the effect is not related to the polarization of the field. The theoretical interpretation of this finding is currently under development.

Conclusion: The left-right B_1^+ asymmetry typically observed in the head at 7 T is linked to a front-back asymmetry in the load, namely the nasal cavity.

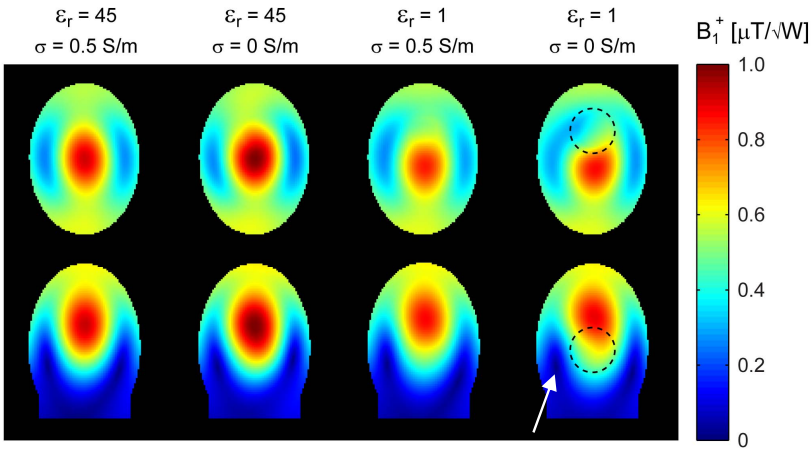

Figure 3. Simulated B_1^+ in the transverse (top) and sagittal (bottom) view for different dielectric properties of the sphere (dashed circle).

References: [1] Zhang et al., *Proc. ISMRM 2013*, 2816;
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