Calculation of the Ultimate Intrinsic Signal to Noise Ratio for a Lossy Elliptic Cylinder

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A key parameter affecting the quality of the images in Magnetic Resonance Imaging (MRI) is the Signal to Noise Ratio (SNR), where the signal is the circularly polarized component of the B_1 field (useful to excite the nuclei to a state where they produce a detectable signal), and the noise which is given by many factors, such as the radiofrequency emissions due to thermal motion and the resistivity of the receiving coils.

Recently, the concept of Ultimate Intrinsic SNR (UISNR) has been introduced (R. Lattanzi, D. K. Sodickson, "Ideal current patterns yielding optimal signal-to-noise ratio and specific absorption rate in magnetic resonance imaging: computational methods and physical insights". Magnetic Resonance in Medicine (2012) 6 8:286-304) to evaluate the quality of a RF coil for a given subject. The UISNR is independent of any coil geometry and depends only on the geometry and electromagnetic properties of the inspected subject. Hence, UISNR is a useful tool to determine how much improvement is still possible to achieve respect to the SNR obtained with a given RF coil. In addition, it indicates the optimal current distributions on the external surface of the subject, which is a relevant information to design optimal RF coils.

In the same paper where the concept of UISNR has been introduced, the optimal current distribution for a circular cylinder has been calculated. In this work, we provide a semianalytical solution to compute the UISNR and the optimal current distribution for a cylinder having an elliptical cross-section, which is a geometry closer to the real human anatomy. This approach also allows to simulate the field distribution in cylindrical phantoms with elliptic cross section instead of the most common circular cylindrical phantoms. In addition, even though these results are obtained for a simplified model of the human body, they constitute a valuable starting point to exploit in further studies where the RF coils designed by observing the currents on the surface of the cylinder are tested and evaluated on more realistic human models.