MRE Reconstruction: Inverting the wave equation

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Outline of This Talk

1. Why we need MRE

2. Data Reconstruction and current Problems

Why do we need MRE?

E. Barnhill et al./Medical Image Analysis 35 (2017) 133–145

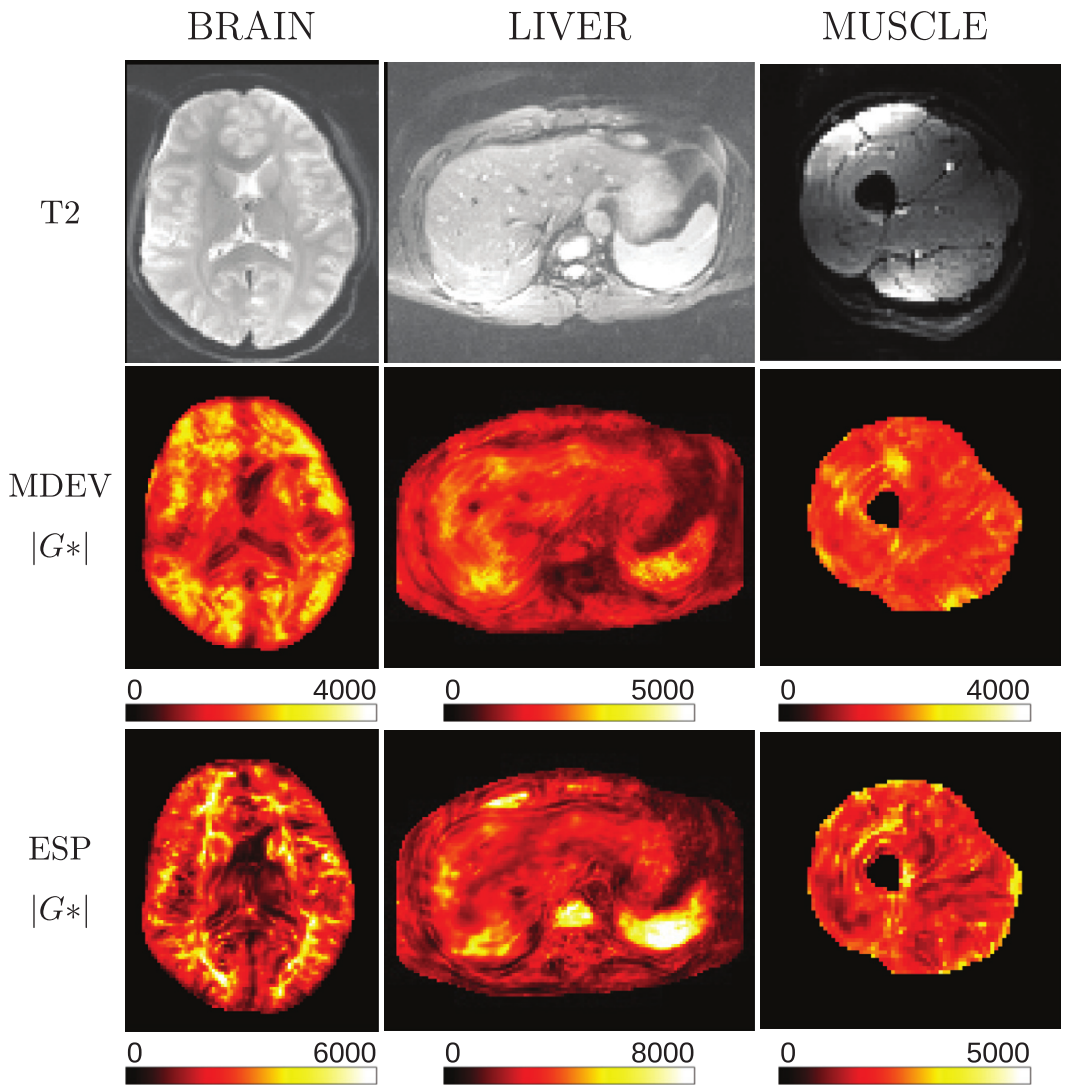

Fig. 9. Comparison of $|G^*|$ and φ maps using the MDEV and ESP pipelines. All values are in Pascals.

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- diseased tissue changes mechanical

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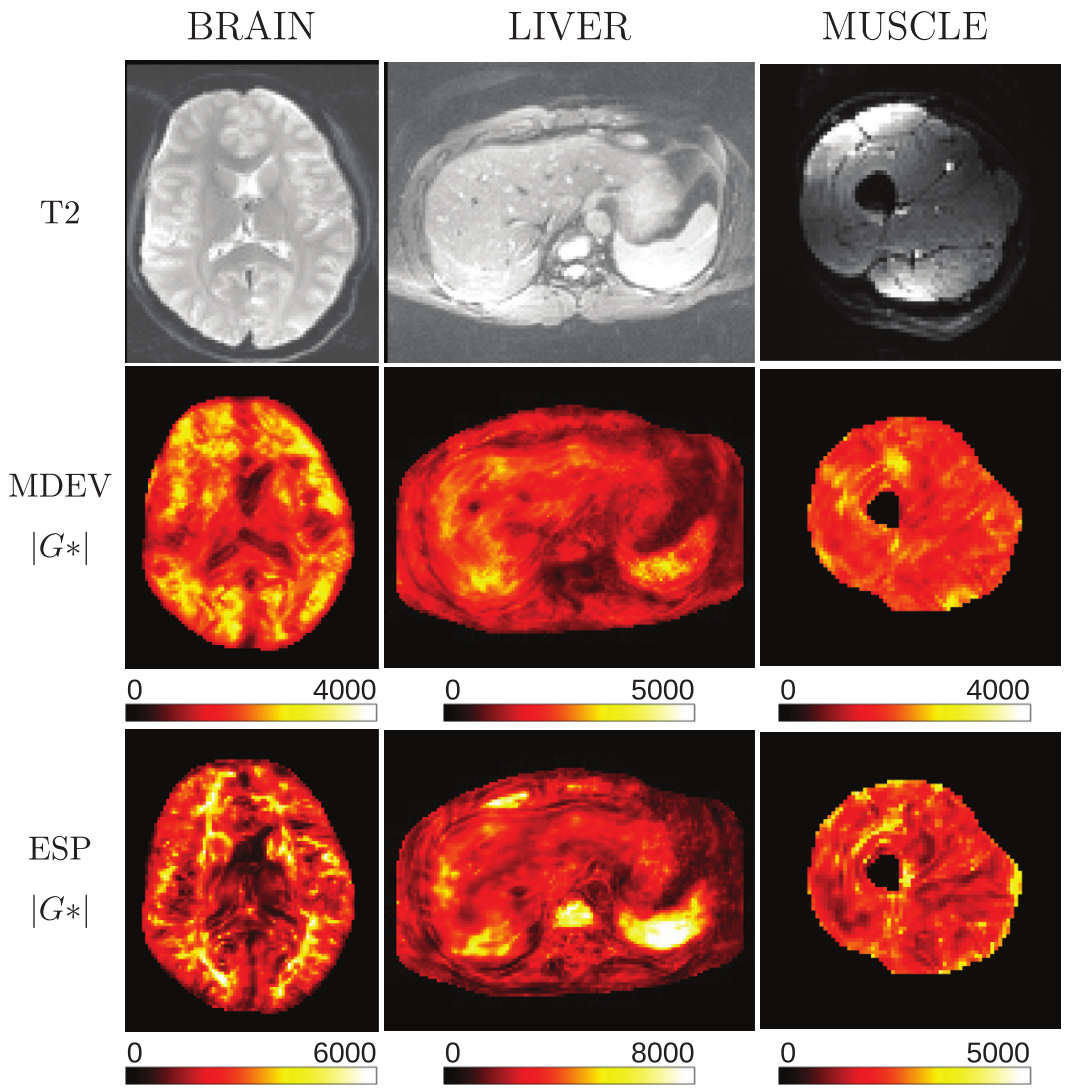

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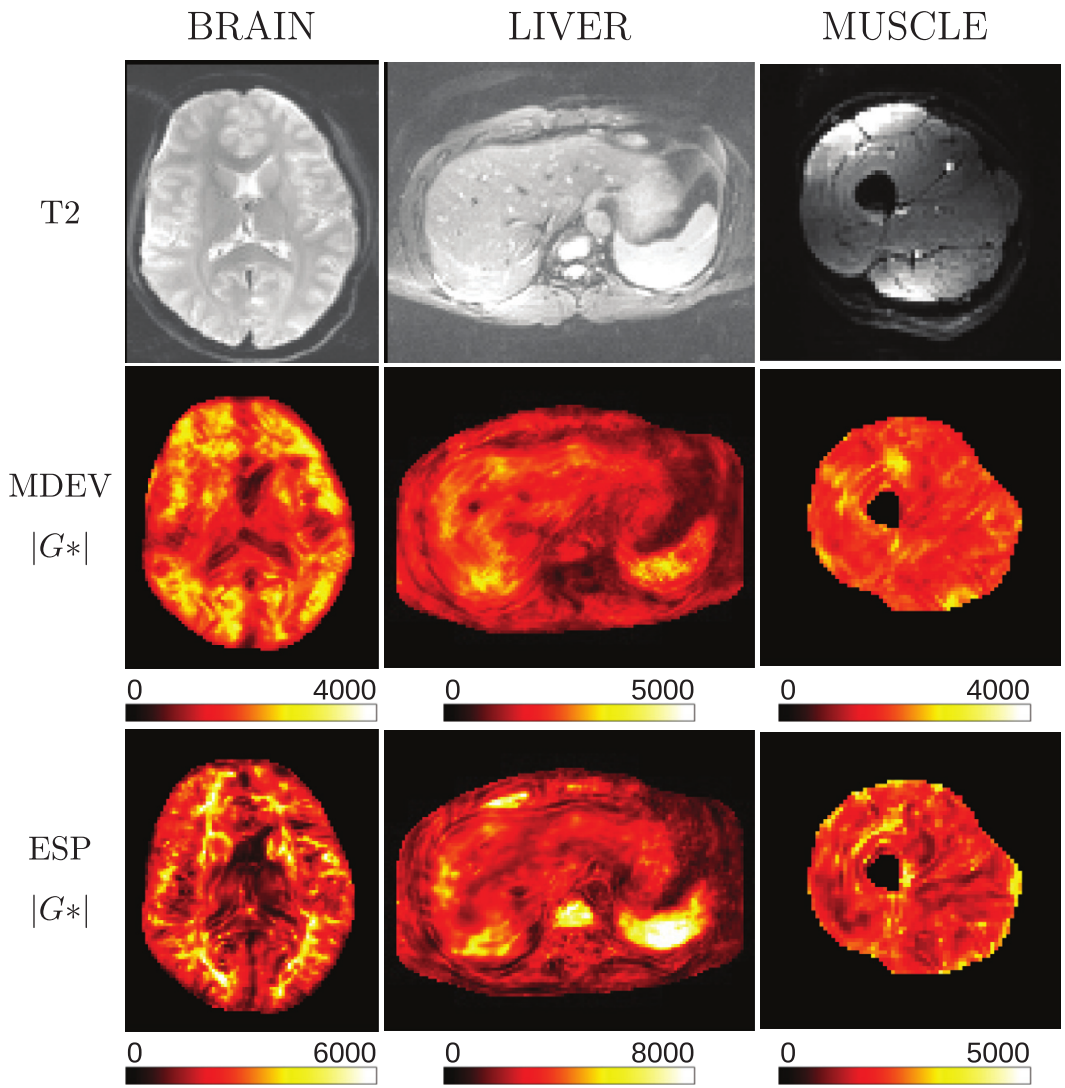

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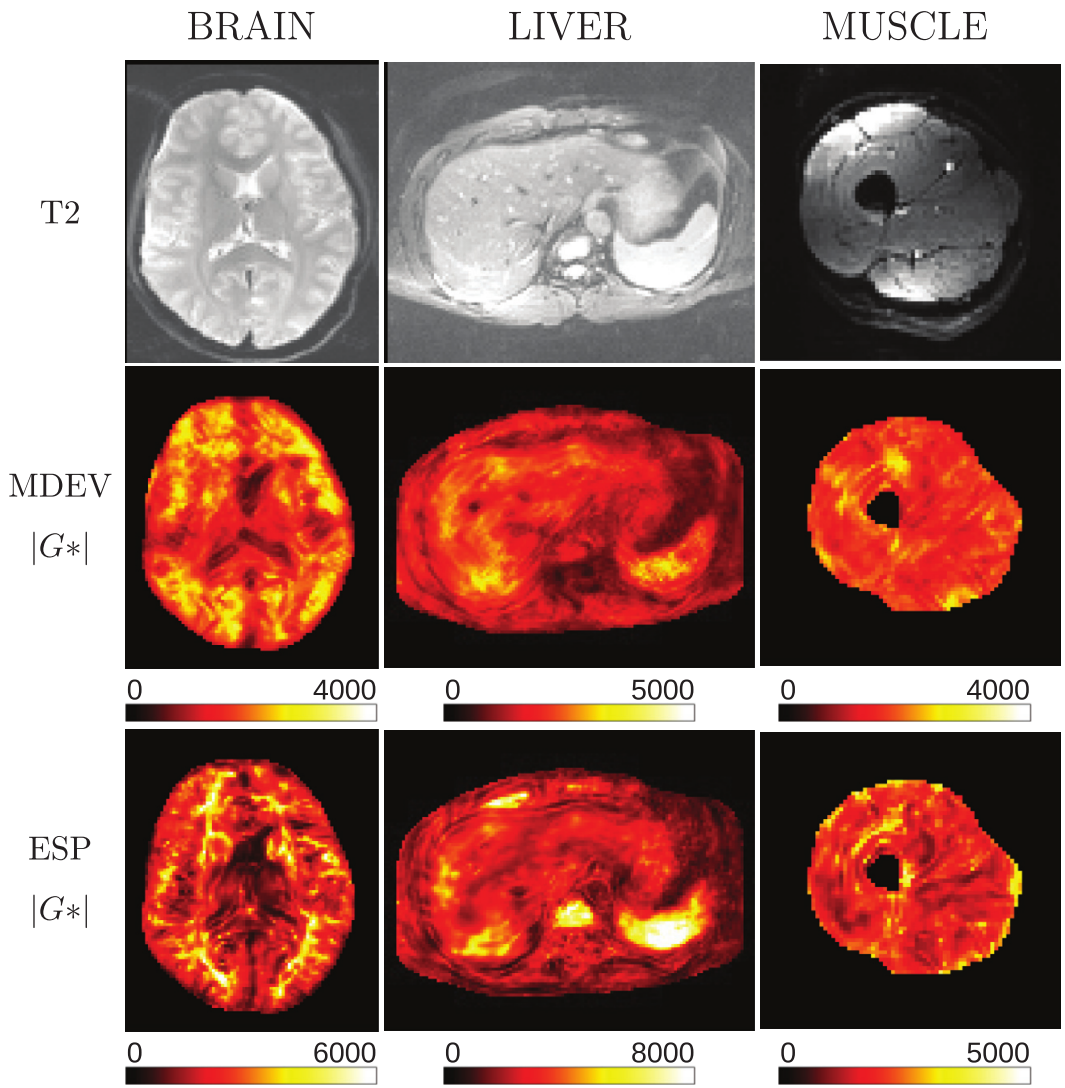

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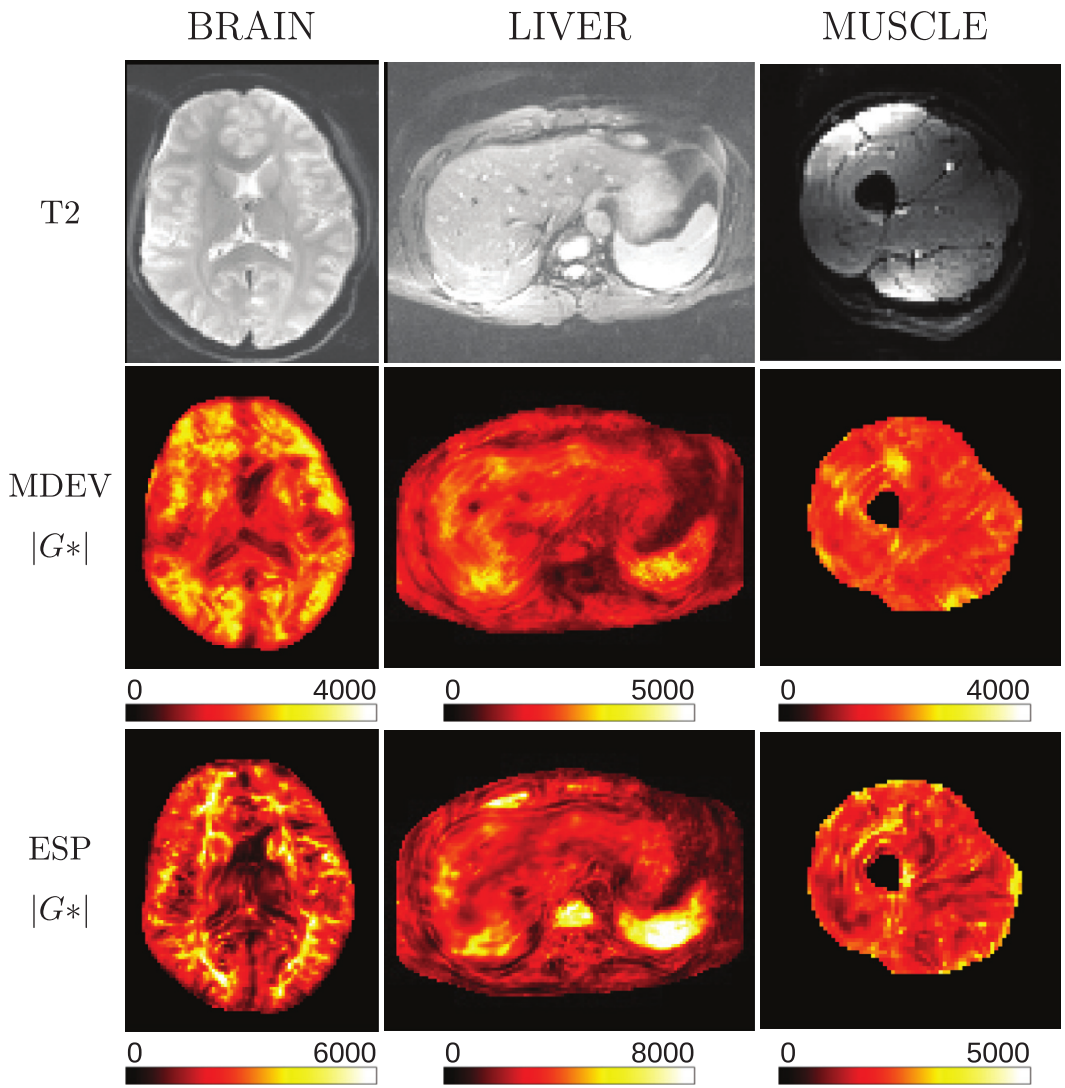

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Why do we need MRE?

- diseased tissue changes mechanical
- low tech: palpation
- higher tech: ultrasound
- highest tech: MRE
- for deep tissue and brains, but non-invasive

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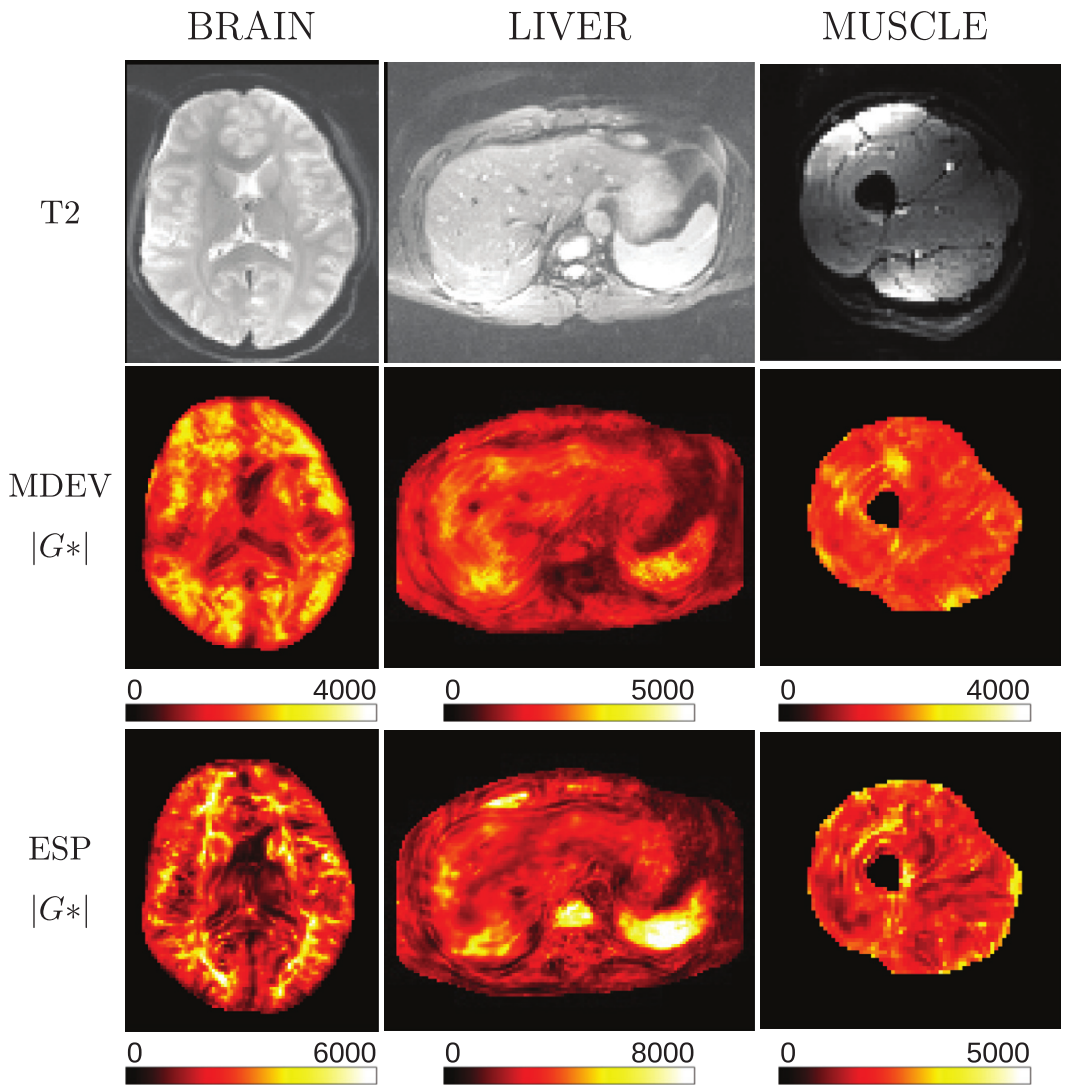

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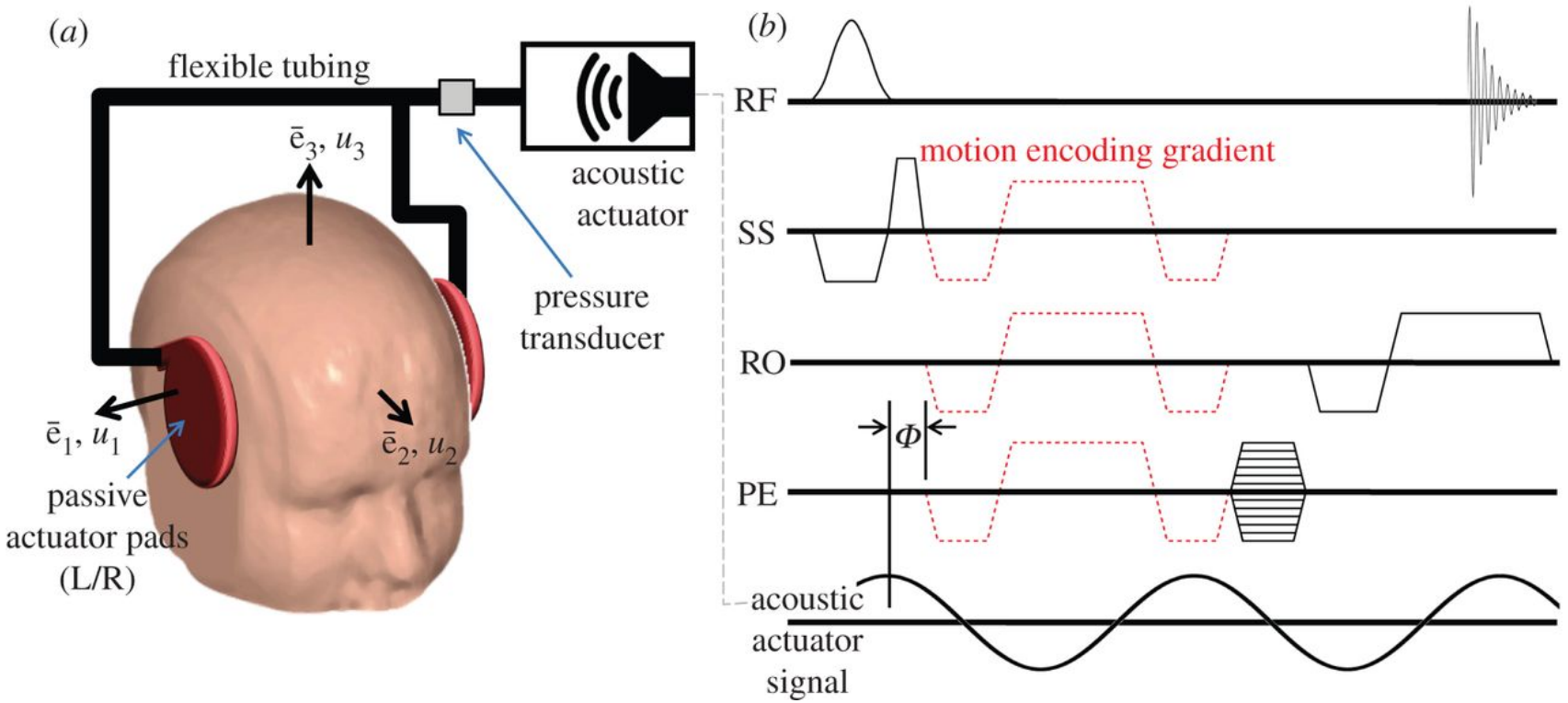
How does the measuring process work



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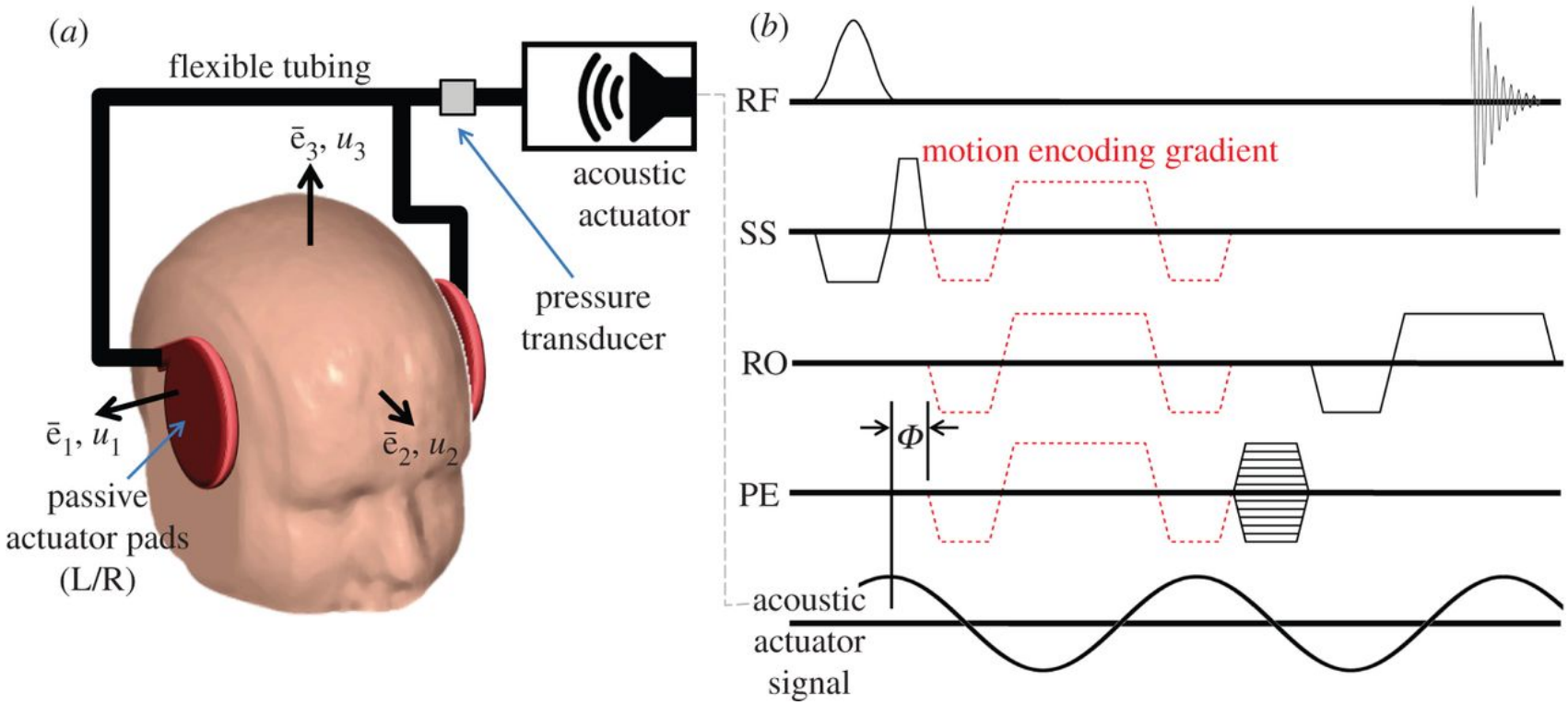

- 3 spatial directions $\times$ 8 time steps $\times$ 3 frequencies

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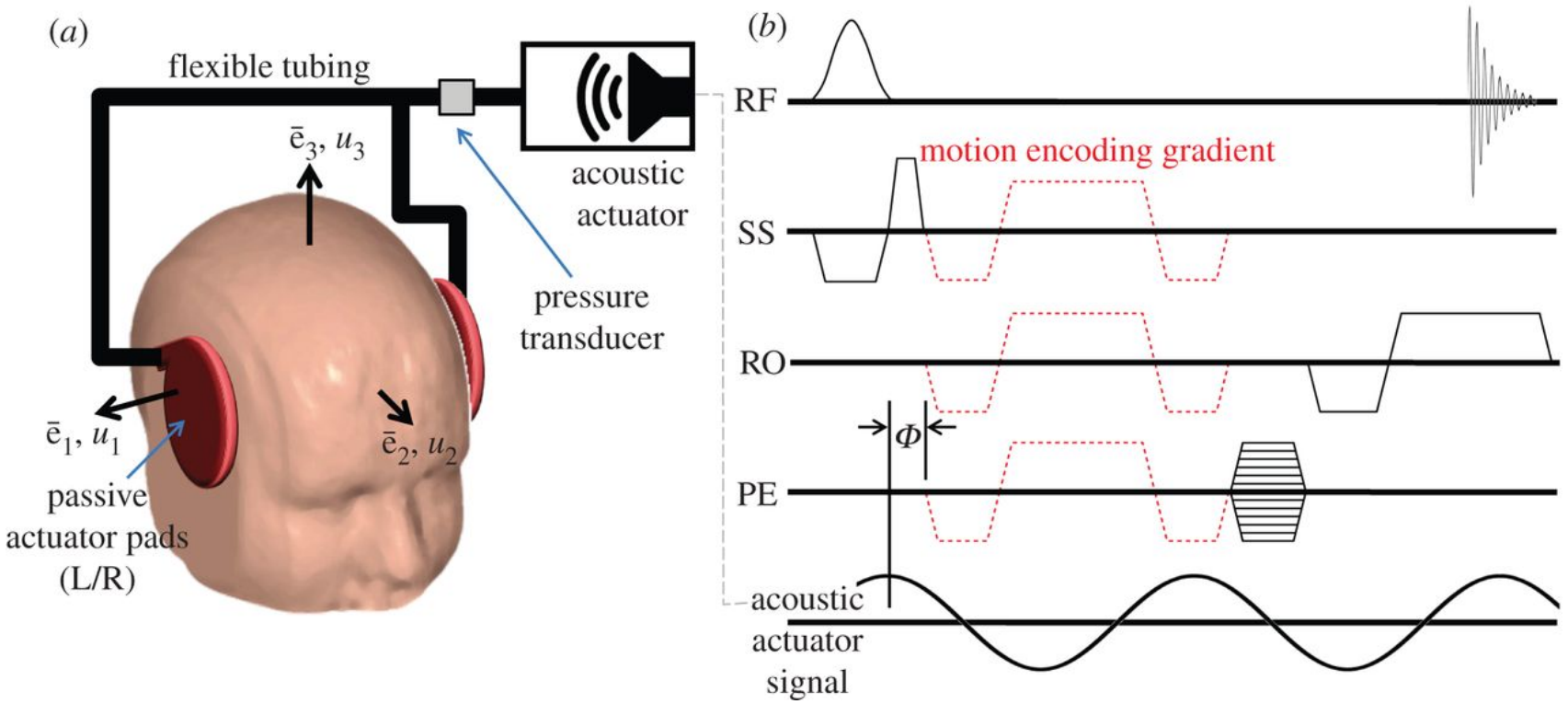

- 3 spatial directions $\times$ 8 time steps $\times$ 3 frequencies
- 72 times longer per pixel than MRI

Data reconstruction

$$\mathbf{u} = \mathbf{u}(\mathbf{x}t)$$

$$\mu =$$

$$\sum_j \partial_j \left(\mu \left(\partial_j u_i + \partial_i u_j\right)\right) + \partial_i \left(\lambda \partial_j u_j\right) = \rho \ddot{u}_i$$

- differential equation –¿ inverse problem
- Problem underdetermined, we need boundary values
- Problem: some regions are close to nodes –¿ no movement
- Solution: Multi frequency inversion
- Problem: Need to reconstruct the derivatives
- motion encoding gradient
- MRI measurement in 3 spatial directions and 8 time steps

- MRI measurement in 3 spatial directions and 8 time steps and 3 frequencies –¿ 72 times MRI overhead
- –¿ reduced resolution

- Problem: Need to reconstruct the derivatives
- slight noise can lead to totally wrong derivatives –¿ inversion is useless
- MRI measurement in 3 spatial directions and 8 time steps

Our plan of work

- Do simuations in 1d: wavelets
- Do simulations in 2d: wavelets, shearlets
-

- Problem: Need to reconstruct the derivatives
- slight noise can lead to totally wrong derivatives –¿ inversion is useless
- MRI measurement in 3 spatial directions and 8 time steps –¿

What would be nice results

- Have better resolution of the stiffness map
- Have clinically useful values, at the moment to varying
- Have shorter acquisition times per pixel

- Problem: Need to reconstruct the derivatives
- slight noise can lead to totally wrong derivatives –¿ inversion is useless
- MRI measurement in 3 spatial directions and 8 time steps –¿