Spectroscopic imaging of a cell suspension

Laure GIOVANGIGLI, École Normale Supérieure

The electric behavior of a biological tissue under the influence of an electric field at angular frequency ω can be characterized by its effective admittivity $k_{ef} := \sigma_{ef} + i\omega\varepsilon_{ef}$, where σ_{ef} and ε_{ef} are respectively its effective conductivity and permittivity [2]. Electrical Impedance Spectroscopy measure the admittivity across a a range of frequencies producing a spectrum showing the change of admittivity with frequency. The aim of my talk is to prove that this spectrum carries information on the microscopic structure of the medium. I study the case of a periodic and dilute repartition of cells in the medium.

I first derive a rigorous homogenization theory to describe the effective admittivity of periodic cell suspensions. Then, for dilute cell suspensions, I use layer potential techniques to expand the effective admittivity in terms of cell volume fraction. This expansion can be expressed in terms of a membrane polarization tensor, M, that depends on the operating frequency ω. We retrieve the Maxwell-Wagner-Fricke formula for concentric circular-shaped cells. The two eigenvalues of the imaginary part of M are maximal for frequencies $1/\tau_i, i = 1, 2$, of order of a few MHz with physically plausible parameters values. This dispersion phenomenon well known by the biologists is referred to as the β-dispersion. The associated characteristic times τ_i correspond to Debye relaxation times. Given this, I show that different microscopic organizations of the medium can be distinguished via $\tau_i, i = 1, 2$, alone. The relaxation times τ_i are computed numerically for different configurations: one circular or elliptic cell, two or three cells in close proximity. The obtained results illustrate the viability of imaging cell suspensions using the spectral properties of the membrane polarization. The approach can be extended to the random case by considering a randomly deformed periodic medium.

The presented results have potential applicability in cancer imaging, food sciences and biotechnology, and applied and environmental geophysics.

This work is a collaboration with H. Ammari, J. Garnier, W. Jing and J.-K. Seo [1].

Références

[1] H. Ammari, J. Garnier, L. Giovangigli, W. Jing and J.-K. Seo, *Spectroscopic imaging of a dilute cell suspension*, submitted to Archive on Rational Mechanics and Analysis, September 2013, arXiv:1310.1292.

[2] Ø. G. Martinsen, S. Grimnes, and H. P. Schwan, *Interface phenomena and dielectric properties of biological tissue*, In Encyclopedia of Surface and Colloid Science, 2643–2652, Marcel Dekker Inc, 2002.

Laure GIOVANGIGLI, Département de Mathématiques et Applications, École Normale Supérieure, 45, rue d'Ulm, 75005 Paris
laure.giovangigli@ens.fr