*ICEAA-IEEE APWC-USNC URSI RSM 2021, Honolulu, Hawaii, USA, August 9-13, 2021*

# Dielectric Properties Model of the Left Atrium and Left Atrial Appendage for Applications in Cardiac Ablation

Niko Ištuk* [(1)], Emily Porter[(2)], Declan O'Loughlin[(3)] and Martin O'Halloran[(1)], e-mail: niko.istuk@nuigalway.ie
(1) Translational Medical Device Lab, National University of Ireland Galway, Galway, Ireland
(2) Department of Electrical and Computer Engineering, The University of Texas at Austin, Austin, USA
(3) Electronic and Electrical Engineering, Trinity College Dublin, College Green, Dublin 2, Ireland.

Accurate dielectric models for cardiac tissue are key to the design of improved cardiac ablation devices. Historically, the heart has been largely treated as a homogeneous organ in a majority of dielectric studies. However, a recent study has demonstrated the organ to be dielectrically heterogeneous [1]. Debye models for specific heart regions could be used to improve frequency-dependent computational models of the heart. Our focus in this study is on left atrium (LA) and left atrial appendage (LAA), since these structures are often the target of ablation when performing pulmonary vein isolation (PVI) and LAA isolation procedures for treatment of atrial fibrillation (AF) [2-3]. Therefore in this work we conducted an analysis of the dielectric properties of the left atrium and left atrium appendage. The goal was to calculate the optimal parameters of a three-pole Debye model for these two important regions of the heart.

The dielectric property data for LA and LAA are part of a larger experimental data, involving many regions of the heart [3]. Specifically, in the experiment, *ex vivo* measurements of the dielectric properties of 19 distinct regions of the heart were performed using an open-ended coaxial probe. The measurement data was acquired from four ovine hearts, with 15 measurements taken for each heart region. The Keysight 5063A ENA was used for the measurements on the first two hearts (200 MHz – 8.5 GHz) and the Agilent E8362B PNA for measurements on the other two (200 MHz – 20 GHz). A total of 240 measurements were taken in the LA and the LAA regions: 120 measurements per region. The data and metadata was collected in line with the Minimum Information for Dielectric Measurements of Biological Tissues (MINDER) guidelines and has been made available online [4].

In the analysis, we assessed the measurement uncertainty and compensated for differences in temperatures between measurements. We then collated the measurements corresponding to the same cardiac region, and established the most accurate values of three-pole Debye model parameters. We used two different optimization techniques for Debye parameter fitting and selected the best set of parameters with the smallest average fractional error between the fit and the data. We compared the results for the parameters of the model for each region with the parameters of the three-pole Debye model for the heart from the literature [5-6], and identified significant differences. This means that these two regions have different dielectric properties to themselves and to historical models of the heart, and therefore should be modelled with different parameters.

In a practical clinical scenario, the Debye model parameters for the LA and the LAA could help better predict the size of the RF lesions during PVI and LAA isolation. The study highlights that the heart is not a dielectrically homogeneous organ, and different regions of the heart have different dielectric properties. In cases where the target of the ablation is a specific part of the heart e.g. LA and LAA, incorporating the appropriate dielectric properties model into numerical simulations would be significant improvement over the simplified homogenous heart models developed historically.

This work was supported by the EMERALD project (EU H2020 MSCA grant agreement No. 764479).

1. S. Salahuddin et al., "Demonstration of dielectric heterogeneity of previously assumed homogeneous tissues: examination of the Heart," EuCAP 2018, 2018.

2. P. Kirchhof et al., "2016 ESC Guidelines for the management of atrial fibrillation developed in collaboration with EACTS," Eur. Heart J., vol. 37, no. 38, pp. 2893–2962, Aug. 2016.

3. N. Ištuk et al., "Detailed Dielectric Characterisation of the Heart and Great Vessels," EuCAP 2020, 2020.

4. E. Porter et al., "Minimum information for dielectric measurements of biological tissues (MINDER): A framework for repeatable and reusable data," Int. J. Rf. Microw. C. E., vol. 28, no. 3, p. e21201, 2018.

5. S. Salahuddin, E. Porter, F. Krewer, and M. O'Halloran, "Optimised analytical models of the dielectric properties of biological tissue," Med. Eng. Phys., vol. 43, pp. 103–111, May 2017.

6. S. Gabriel, R. W. Lau, and C. Gabriel, "The dielectric properties of biological tissues: III. Parametric models for the dielectric spectrum of tissues," Phys. Med. Biol., vol. 41, no. 11, pp. 2271–2293, Nov. 1996.