Review of: "A memory dependent analysis on permeation of non-Gaussian laser pulse through human skin"

Muhammad Arif Mahmood[1]

1 Missouri University of Science and Technology

Potential competing interests: No potential competing interests to declare.

Mertis:

- The manuscript presents a thermodynamic analysis of laser treatment on human skin using a bi-layer skin model with epidermis and dermis layers. This provides a more realistic model than studying skin as a single layer.
- It uses a memory-dependent heat conduction model rather than the classical Pennes bioheat model. The memory-dependent model can better capture the thermal behavior and stress/strain response of skin tissue.
- The non-Gaussian temporal profile of the laser pulse is incorporated, which is more realistic than using an ideal pulse shape.
- Both the strong absorption (UV wavelength) and the strong scattering (visible/IR wavelength) cases are analyzed. The penetration depth and temperature profiles are compared for these different regimes.
- Analytical solutions for the temperature, stress, and displacement fields are derived using Laplace transforms and eigenvalue techniques. This allows the study of the spatial and temporal evolution.
- The analytical results are validated by comparing them to experimental observations on the light penetration depth into the skin. Reasonable agreement is found.
- The model provides insight into how the laser wavelength affects the thermal therapy of skin tissue. This could help optimize treatments.

Weaknesses:

Some potential weaknesses or limitations of the manuscript include:

- The model makes some simplifying assumptions about the skin layers - treating them as homogeneous, isotropic, and linear. In reality, skin tissue is complex and heterogeneous.
- Only 1D heat transfer is analyzed. The effects of lateral heat spreading are neglected.
- The interfacial conditions between the epidermis and dermis may be oversimplified. Thermal contact resistance could be important.
- Only two wavelengths are examined. More examples could give a broader perspective.
- The perfusion effects of blood flow are incorporated in a simplified manner through the bioheat equation. More complex vascular effects are ignored.
- The metabolic heat term is neglected. This may be reasonable for short times but could be relevant.

- Quantitative validation is limited. More comparisons to measured temperature/damage data could help validate the model.
- The model is theoretical in nature. The practical implications for laser treatment parameters could be explored more.
- The prose could be tighter in places to more clearly convey key information.
- There appear to be some minor typos/grammatical errors that need fixing.

The analysis is solid, but the model makes trade-offs between complexity and tractability. More rigorous validation and discussion of practical implications in a laser medicine context could strengthen the paper. But these are common issues when balancing theory and experiments.

Comments on artwork:

Regarding the artwork in the manuscript:

- Figures 1 and 2:

The diagrams clearly illustrate the anatomy of skin layers and the model geometry. Using these aids the textual description.

- Figures 3:

The laser pulse temporal profile plot is effective at conveying the non-Gaussian shape.

- Figures 4-9:

The plots of temperature, stress, and displacement profiles versus depth provide useful visualization of the model results.

- Different line styles and colors allow comparison of the memory-dependent model versus the classical Pennes model (in Figs. 4-6). This highlights the differences.
- Separate plots for the two laser wavelengths (in Figs. 7-9) enable seeing the variation with optical parameters.

The figures are simple but informative. They support the analytical results well. A few thoughts for improvement:

- Axis labels could be made larger/clearer in some plots.
- Adding a legend box would prevent having to refer back to the caption so much.
- Some additional annotations on the plots could highlight key points.
- Figures could potentially be combined to reduce the overall number.

The visuals aid the reader in understanding the modeling results and analysis. The manuscript provides a good balance of equations, methodology, results, and figures.