Abstract Submitted
for the MAR08 Meeting of
The American Physical Society

Dynamics of Gas Exchange through the Fractal Architecture of the Human Lung, Modeled as an Exactly Solvable Hierarchical Tree
MICHAEL MAYO, PETER PFEIFER, Department of Physics, University of Missouri, Columbia, MO, 65211, STEFAN GHEORGHIU, Center for Complexity Studies, Aleea Parva 5, Bucharest 061942, Romania — The acinar airways lie at the periphery of the human lung and are responsible for the transfer of oxygen from air to the blood during respiration. This transfer occurs by the diffusion-reaction of oxygen over the irregular surface of the alveolar membranes lining the acinar airways. We present an exactly solvable diffusion-reaction model on a hierarchically branched tree, allowing a quantitative prediction of the oxygen current over the entire system of acinar airways responsible for the gas exchange. We discuss the effect of diffusional screening, which is strongly coupled to oxygen transport in the human lung. We show that the oxygen current is insensitive to a loss of permeability of the alveolar membranes over a wide range of permeabilities, similar to a "constant-current source" in an electric network. Such fault tolerance has been observed in other treatments of the gas exchange in the lung and is obtained here as a fully analytical result.

Michael Mayo
Department of Physics, University of Missouri, Columbia, MO, 65211

Date submitted: 26 Nov 2007 Electronic form version 1.4