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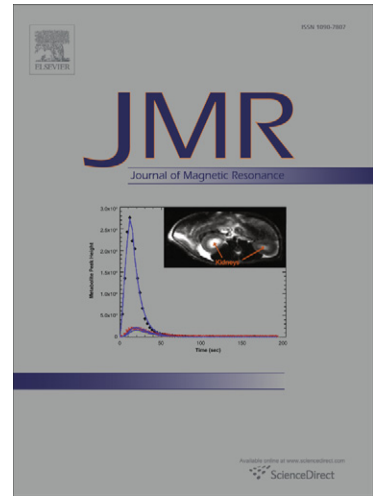

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Fred K. Gruber, Lalitha Venkataramanan, Tarek M. Habashy, Denise E. Freed

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Estimation of Petrophysical and Fluid Properties using Integral Transforms in Nuclear Magnetic Resonance

Fred K. Gruber, Lalitha Venkataramanan*, Tarek M. Habashy, Denise E. Freed

Schlumberger-Doll Research, One Hampshire Street, Cambridge, MA 02139

Abstract

In the past decade, low-field NMR relaxation and diffusion measurements in grossly inhomogeneous fields have been used to characterize properties of porous media, e.g., porosity and permeability. Pulse sequences such as CPMG, inversion and saturation recovery as well as diffusion editing have been used to estimate distribution functions of relaxation times and diffusion. Linear functionals of these distribution functions have been used to predict petro-physical and fluid properties like permeability, viscosity, fluid typing, etc. This paper describes an analysis method using integral transforms to directly compute linear functionals of the distributions of relaxation times and diffusion without first computing the distributions from the measured magnetization data. Different linear functionals of the distribution function can be obtained by choosing appropriate kernels in the integral transforms. There are two significant advantages of this approach over the traditional algorithm involving inversion of the distribution function from the measured data. First, it is a direct linear transform of the data. Thus, in contrast to the traditional analysis which involves inversion of an ill-conditioned, non-linear problem, the estimates from this new method are more accurate. Second, the uncertainty in the linear functional can be obtained in a straight-forward manner as a function of the signal-to-noise ratio (SNR) in the measured data. We demonstrate the performance of this method on simulated data.

Keywords: Integral transform, Analysis of exponentially decaying data, Analysis of NMR data in inhomogeneous fields, Inverse Laplace transform, NMR logging

1. Introduction

Our study has been guided by NMR applications in porous media such as rocks and well-logging. For example, NMR can provide certain properties of

*Corresponding author
Email address: LVenkataramanan@slb.com (Lalitha Venkataramanan)