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**Magnetization components of moving nuclear spin under NMR/MRI excitation (I)**
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In the heart of NMR/MRI Imaging science & technology lie the components of magnetizations (specially My and Mz when rf B1 field is lying along a laboratory axis, say, X-direction). The components and consequently the detected MR signals/images depend in a complicated way on magnetic fields (bias and gradient fields), relaxation times, rf B1 field (pulsed or continuous), relaxation times, blood(nuclear spin) flow velocity and rates, diffusion of spins, density of spins etc. The last four quantities are of clinical importance (for diagnosis of tissues and blood flow estimation) which is to be extracted from the MR images or signals. Understanding of such dependencies clearly is very crucial to the medical diagnosis that depends on MR images/signals. NMR Bloch equations provide coupled differential equations involving the components of magnetization. The simulation of the images done so far has not used the exact correct relationship of the single component My and Mz (which produce signals in a detector) on the above quantities. The main purpose of this work is to develop and show the pathway for finding the true relationship of individual My and Mz component with the said quantities, using the fundamental Bloch equations.

We have adapted two methods (i) operator formalism (ii) gradual elimination of variables from the coupled differential equations to obtain two compact differential equations one containing only My and the other containing only Mz component of the magnetization in presence of rf B1 field and spin flow which can depend on both space and time coordinates.

The derived equations are referred to the rotating frame of reference. We have given the transformation equation from rotating frame of reference to the laboratory frame of reference, which can be used to transform the My and Mz components (that can be obtained from the solutions of the compact differential equations) in the rotating frame to that in the laboratory frame. We have also given expressions for the signal to be expected from either of the magnetization component (depending on detector orientation) in the rotating frame of reference using the above two approaches. We found that though the two approaches yield two apparently looking different equations for My, on analysis they turn out to give the same equation for My. The same holds for Mz (whose equation is different from that of My). These newly developed equations yield the same known equations for My and Mz in absence of flow of spins (blood in clinical sense) at resonance (CW) in the laboratory frame. We find that the developed equations are unique and for the first time describe the true relationship between individual single components My, Mz with the above quantities (excluding diffusion and gradient fields). The equations are applicable for both CW and pulsed NMR experiments with or without flow of spins. Our approaches can be extended easily to include gradient fields and diffusion of spins, and to transform to laboratory frame, if needed. We also discuss the methods of application of our equations to two specific cases of MR excitation scheme: Free induction decay and spin echo to obtain the correct expressions for the magnetization components.

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