

Magn. Reson. Discuss., community comment CC2  
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## **Comment on mr-2021-50**

Malcolm Levitt

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Community comment on "The Lindbladian form and the reincarnation of Felix Bloch's generalized theory of relaxation" by Thomas M. Barbara, Magn. Reson. Discuss., <https://doi.org/10.5194/mr-2021-50-CC2>, 2021

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The old Bloch and Hubbard articles are very deep but for the most part very difficult to read, and it's not surprising that some of this work was overlooked in favour of the inhomogeneous master equation with its awkward  $\rho_{eq}$  "fudge factor". That equation looks intuitively obvious and served the purpose well for many years. Tom Barbara has done a great job in excavating this literature and uncovering the close relationship between the Bloch/Hubbard formulation and the Lindbladian theory of relaxation (or more rigorously, the Gorini–Kossakowski–Sudarshan–Lindblad theory), which was developed much later by an entirely different community of theorists, and only recently applied to magnetic resonance, leading us full circle.

More surprising, perhaps, is that Abragam also seemed to have overlooked the Bloch/Hubbard work in his book. Although Abragam's book is close to being a masterpiece it is not completely free from flaws. It is worth re-reading the sections on the master equation where Abragam attempts a rigorous justification for the inhomogeneous master equation, but his reasoning runs into the sand with no definitive conclusion. Basically he tried to correct the double-commutator form of the relaxation theory by including some thermal correction factors. We now understand that this approach fails (although it has some defenders, including an obstinate reviewer who used this argument to reject our own master equation paper) and that the Lindblad form is required. Thanks to Tom we now know that Bloch and Hubbard had anticipated Lindblad by many years.