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The principles of dynamic nuclear polarisation with strong microwave fields. From the solid effect to NOVEL and ISE

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Dynamic Nuclear Polarization (DNP) uses microwave power to transfer the – high – polarization of electron spins to nuclear spins. To speed up this transfer, it is often attractive to increase the microwave power, i.e., increase the strength of the microwave field. This talk discusses how one passes through different regimes when doing so. At low power the solid effect and thermal mixing contribute to the polarization transfer on equal footing. But only in the weakest microwave fields thermal mixing leads to equal spin temperatures for unequal types of nuclear spins. Upon further increasing the microwave power, the solid effect takes over and eventually dominates the polarization transfer completely. In all these regimes the transfer can be described by means of rate equations: linear equations yielding an exponential growth or decay of the polarization. So the method of rate equations is surprisingly robust and valid in a wide range of microwave powers. Only in the strongest microwave fields the description with rate equations fails. Then the transfer of polarization becomes coherent and non-linear. For the DNP schemes in this regime, in particular Nuclear Orientation Via Electron spin Locking (NOVEL) and the Integrated Solid Effect (ISE) a completely different approach is needed.

Primary author: Prof. WENCKEBACH, Tom (Paul Scherrer Institute, CH-5232 Villigen)

Presenter: Prof. WENCKEBACH, Tom (Paul Scherrer Institute, CH-5232 Villigen)

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