Nuclear Overhauser effect (NOE)

Alfred Overhauser possibly is the most highly cited scientist in the world if the "O" in NOE is counted as a citation...

The nuclear Overhauser effect is the observation that irradiation (saturation) of the NMR signal of spin A changes the intensity of the NMR signal of spin B. NOEs require that the spins are close together, as the mechanism of magnetization transfer relies on the through-space dipole-dipole interaction between both spins.

Assume a 2-spin system, where spin A and spin B have different frequencies (so that one can selectively irradiate spin A). In thermal equilibrium, the lower energy levels are more highly populated than the higher energy levels. In the diagram below, saturation of spin A leads to equal populations of the levels labelled $\alpha\alpha$ and $\beta\alpha$, and $\alpha\beta$ and $\beta\beta$.

![Diagram](image)

This does not (yet) change the population difference for the transitions between $\alpha\alpha$ and $\alpha\beta$, and $\beta\alpha$ and $\beta\beta$, i.e. the intensity of the signal of spin B is unchanged. However, there are finite probabilities for transitions $W_0$ (between $\beta\alpha$ and $\alpha\beta$) and $W_2$ (between $\beta\beta$ and $\alpha\alpha$). $W_0$ and $W_2$ are zero-quantum and double-quantum transition probabilities.

In large, slowly tumbling molecules, zero-quantum transitions are dominant. This leads to redistribution of the populations and a decreased intensity of the signal of spin B.

![Diagram](image)

In small, rapidly tumbling molecules, double-quantum transitions are dominant. This leads to redistribution of the populations and a increased intensity of the signal of spin B.

![Diagram](image)