Operators for two spins

spin 1	spin 2	description
I_{1x}	I_{2x}	x-magnetization
I_{1y}	I_{2y}	y-magnetization
I_{1z}	I_{2z}	z-magnetization

In this formulation the spins are both named I, which may be useful for homonuclear spin-spin coupling. For example, H-H spin coupling or ^{13}C-^{13}C coupling. However, hetero-nuclear coupling is also common in NMR.

Operators for two spins

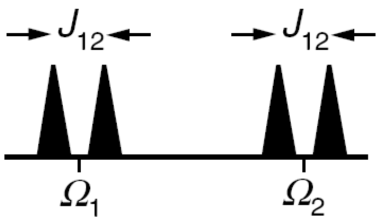
spin 1	spin 2	description
I_x	S_x	x-magnetization
I_y	S_y	y-magnetization
I_z	S_z	z-magnetization

The representation shown here is equivalent to that shown on the previous slide. In fact, the S spin does not have to be a different type of nucleus and some books prefer to use I and S rather than using the I_1 and I_2 of the previous slide.

Operators for two spins

spin 1	spin 2	description
I_{1x}	I_{2x}	x-magnetization
I_{1y}	I_{2y}	y-magnetization
I_{1z}	I_{2z}	z-magnetization

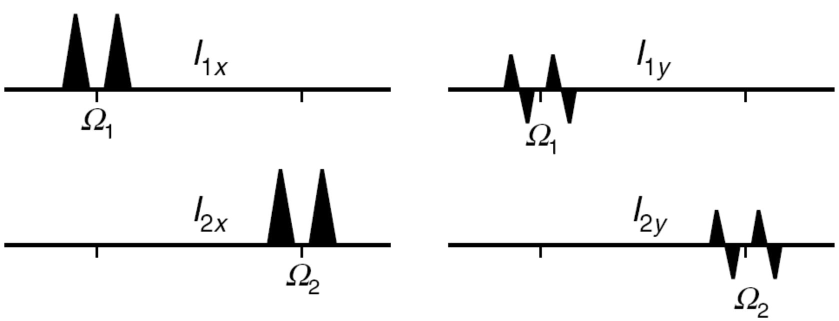
If spins 1 and 2 are coupled then the spectra consists of two doublets. Therefore I_{1x} is further identified with the two lines of the doublet of spin 1 and I_{2x} with the doublet of spin 2.

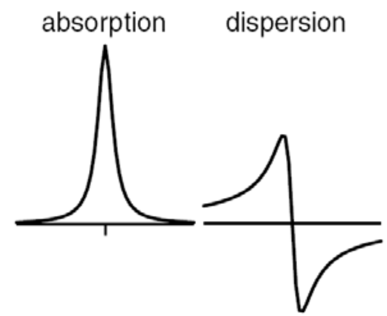


Operators for two spins

I_{1x} represents in-phase magnetization of spin 1. In-phase magnetization implies both lines of the doublet have the same lineshape and sign. Magnetization along the y-axis gives rise to a different lineshape.

Magnetization along x gives rise to an absorption mode lineshape. Magnetization along y gives rise to a dispersion mode lineshape.

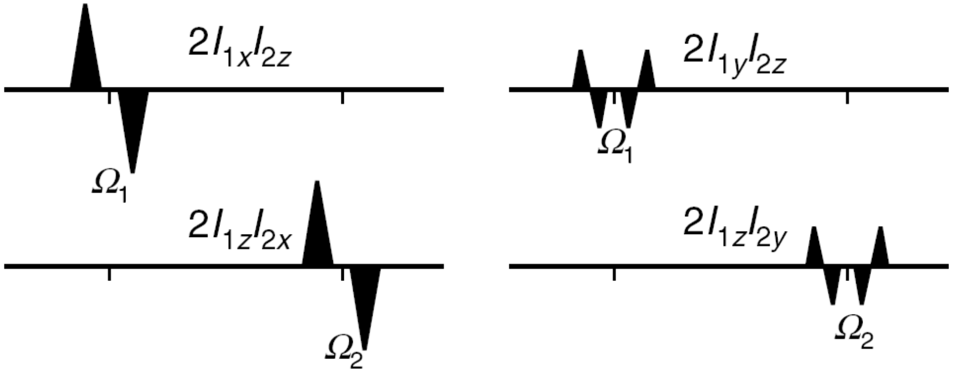




Anti-phase magnetization

The two lines of each doublet represent the α and β spin states of the coupled spin. In an anti-phase multiplet the coupled lines have different signs. Anti-phase operators take into account the α and β spin states spin states of the coupled spins.

For example the operator $2I_{1x}I_{2z}$ describes the magnetization on spin 1 that is anti-phase with respect to the coupling of spin 2.



Operators for two spins

spin 1	spin 2	description
I_{1x}	I_{2x}	x-magnetization
I_{1y}	I_{2y}	y-magnetization
I_{1z}	I_{2z}	z-magnetization
$2I_{1x}I_{2z}$	$2I_{1z}I_{2x}$	anti-phase along x
$2I_{1y}I_{2z}$	$2I_{1z}I_{2y}$	anti-phase along y

non observable (multiple quantum coherences)

$2I_{1x}I_{2y}$, $2I_{1y}I_{2x}$, $2I_{1x}I_{2x}$, $2I_{1y}I_{2y}$

Operators for two spins

spin 1	spin 2	description
I_x	S_x	x-magnetization
I_y	S_y	y-magnetization
I_z	S_z	z-magnetization
$2I_xS_z$	$2I_zS_x$	anti-phase along x
$2I_yS_z$	$2I_zS_y$	anti-phase along y

non observable (multiple quantum coherences)

$2I_xS_y$, $2I_yS_x$, $2I_xS_x$, $2I_yS_y$