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Bloch equation for the description of linear coupling in storage rings

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Linear coupling in storage rings mixes horizontal and vertical beam motion. This is similar to the mixing of states in an atomic two-level system by a resonant laser interaction or the mixing of the two states of any spin-½ particle in static and dynamic external magnetic fields like, for example, in nuclear magnetic resonance, NMR, measurements. These coupled two-level systems are usually described by the Bloch equation [1] which is a set of coupled, first-order differential equations connecting the population of the states with some other parameters which contain in addition to the strength of the coupling and the detuning, some sort of phase information of the involved states. In linearly coupled storage rings horizontal and vertical emittance can be viewed as the population of ground and excited level and it will be shown that the Bloch equations can also model the time-dependent evolution of the transverse emittances of an ensemble of circulating particles. This is especially useful in cases where the emittance is exchanged by crossing the coupling resonance or where the coupling strength itself is a function of time.

[1] F. Bloch, "Nuclear induction,"Physical Review, vol. 70, no.
7-8, pp. 460–474, 1946.

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