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量子スピン系の光誘起相転移 :Haldane相のブレークダウン

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Introduction

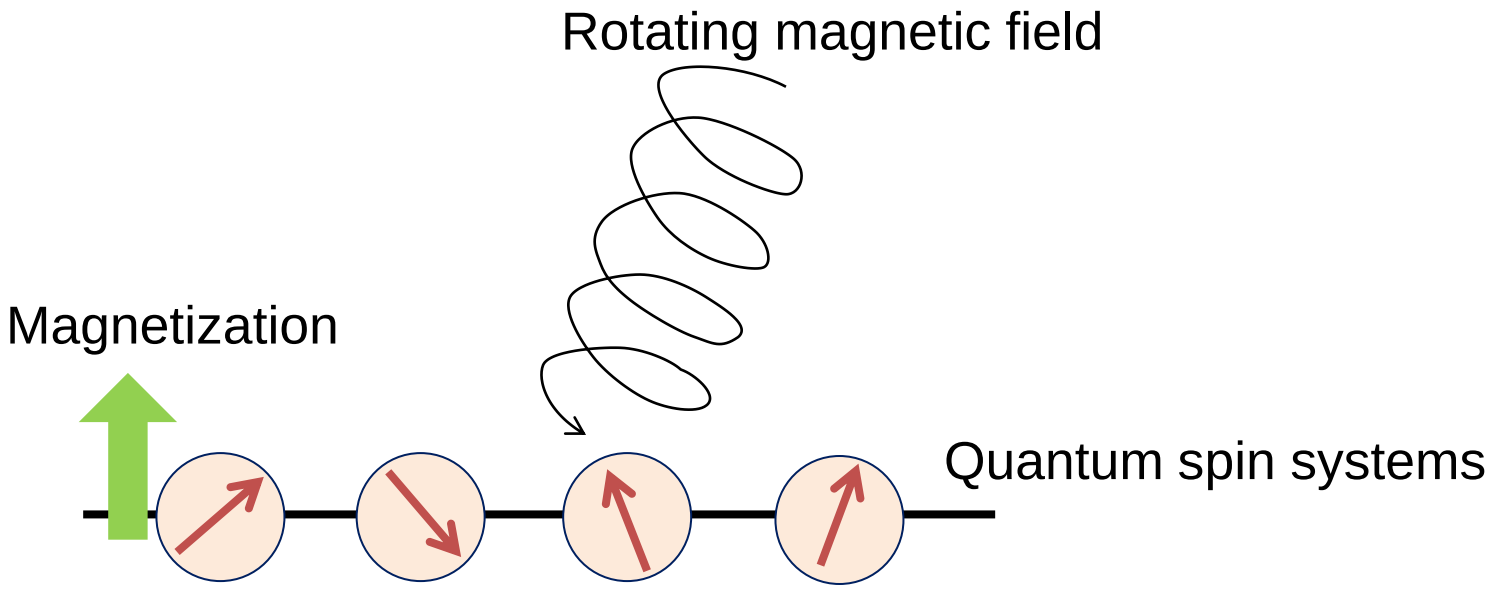


Photo induced phase transition has intensively studied recently.

- Metallization of Mott insulators by photocarriers

- Photo-induced topological phase transition

However, there are only few studies of direct and coherent spin manipulation performed by laser.
The estimated laser frequency is approximately in the THz region.

Main Results

$$\mathcal{H} = \sum_{i=1}^{N} \{ J(S_i^x S_{i+1}^x + S_i^y S_{i+1}^y + S_i^z S_{i+1}^z) + D(S_i^z)^2 + A(\mathrm{e}^{-\mathrm{i}\Omega t} S_i^+ + \mathrm{e}^{\mathrm{i}\Omega t} S_i^-) \}$$

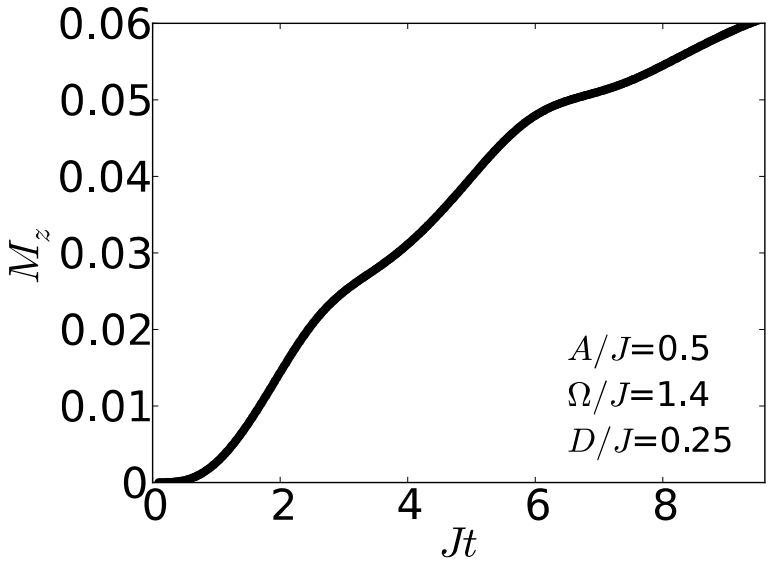
Heisenberg chain with single ion anisotropy

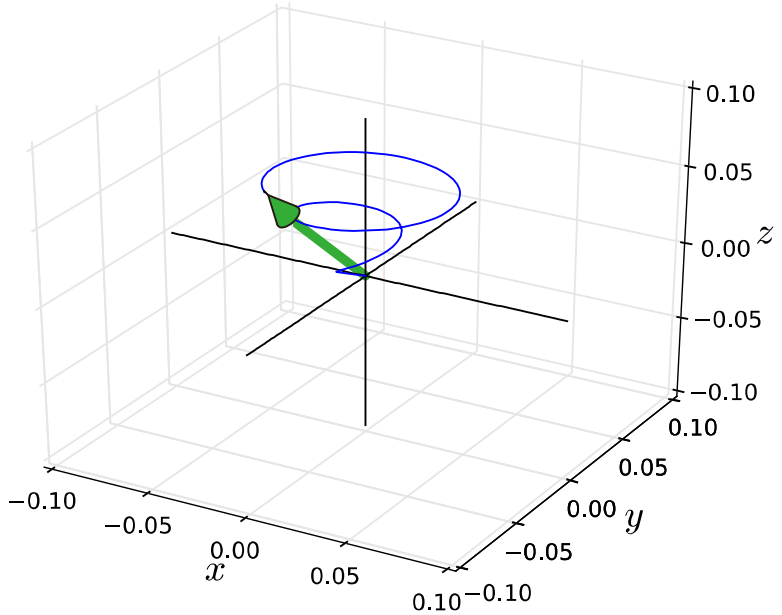
Rotating magnetic field

We use the infinite time-evolving block decimation (iTEBD) method.

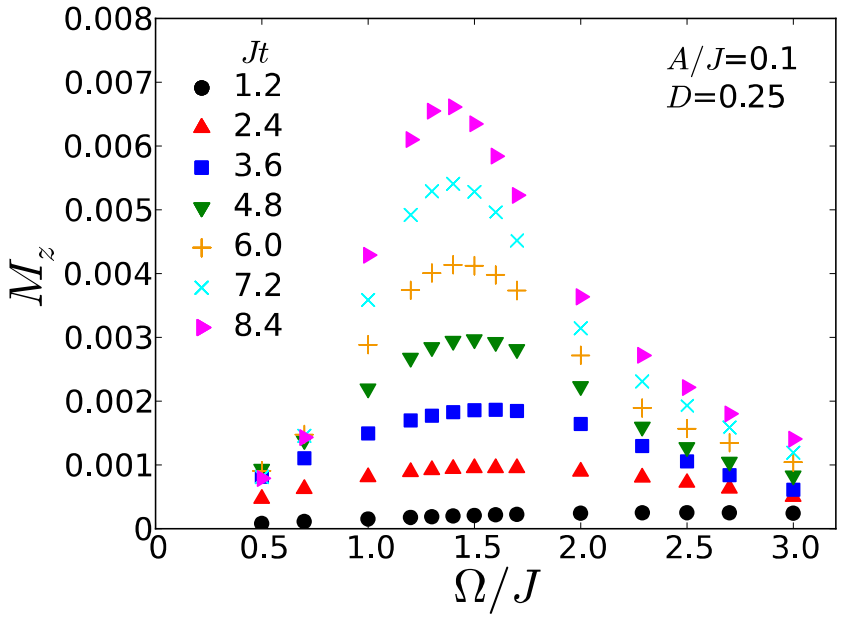
We have found that the application of rotating field in the xy-plane provokes the magnetization along z-axis.

It is different from "spin pumping", in that it is not mediated by electric excitation but is triggered by a direct coherent spin dynamics.





Frequency dependence



The left figure is frequency dependence of induced *z*-magnetization at various times when *A* and *D* is fixed.

The peak gradually appears around $\Omega \sim 1.4J$ as time advances.

In the Floquet theory,

$\Omega \Leftrightarrow$ longitudinal magnetic field

$A \Leftrightarrow$ transverse magnetic field

Magnetization is induced when the Floquet energy levels of ground and ferromagnetic states approach and are repulsed each other.

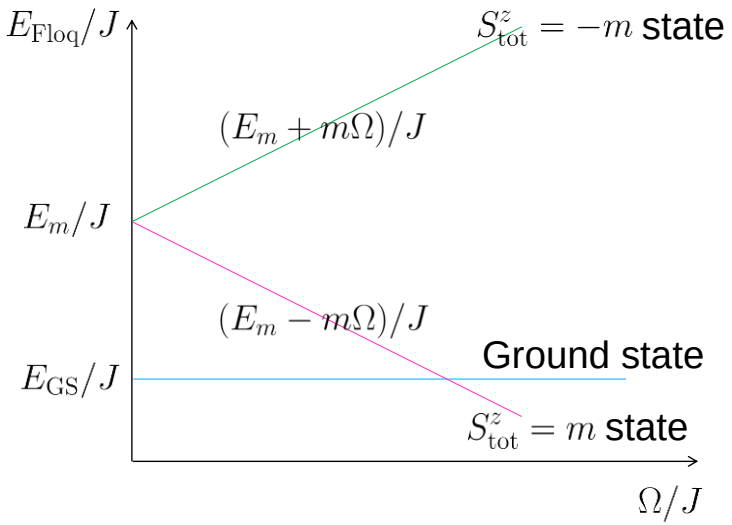
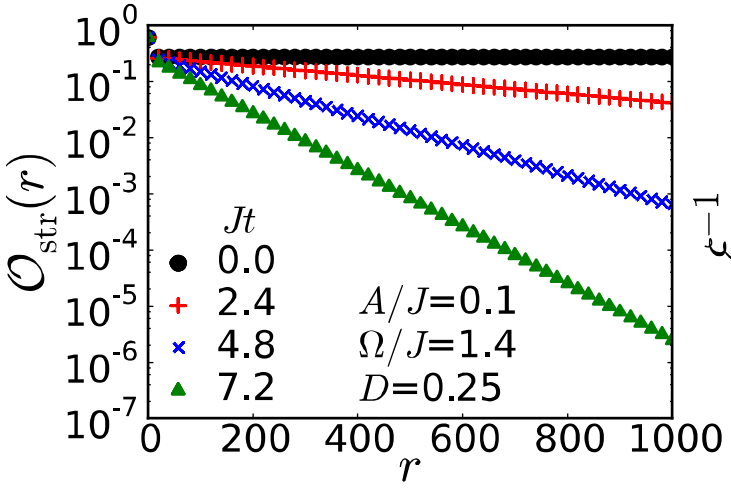
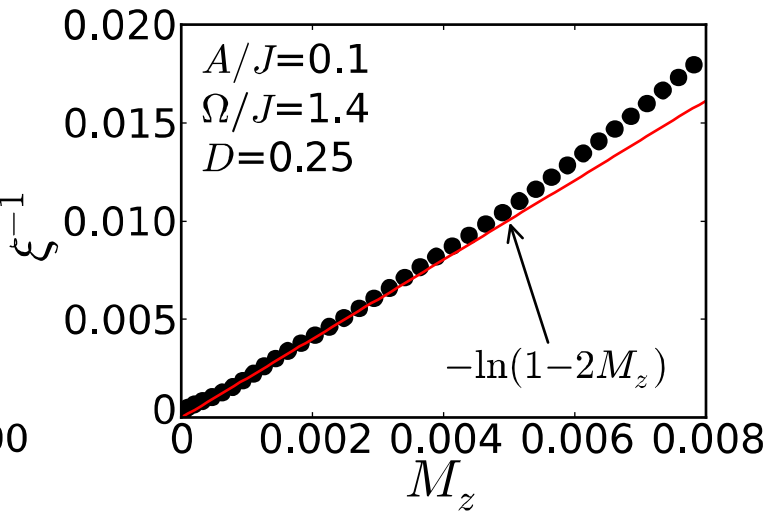


Photo-induced transition from Haldane phase

String order parameter $\lim_{r\to\infty} \mathcal{O}_{\rm str}(r)$ $\quad \mathcal{O}_{\rm str}(r) = \langle S_0^z \exp\left(i\pi \sum_{j=0}^{r-1} S_j^z\right) S_r^z \rangle$

Haldane phase is characterized by non-zero string order parameter.
The string order is broken after the laser radiation due to the magnetization.





Let the initial *r*-site string correlation S_0. Magnetization gives a disorder to a single site with the probability M_z. The string correlation is estimated by adding the probability that *j* out of *r* sites are disordered.

$$S_0 \left[\binom{r}{0} (1-M_z)^r - \binom{r}{1} M_z^1 (1-M_z)^{r-1} + \binom{r}{2} M_z^2 (1-M_z)^{r-2} - \binom{r}{3} M_z^3 (1-M_z)^{r-3} + \cdots \right]$$

$$= S_0 (1-2M_z)^r \longrightarrow \xi^{-1} = -\ln(1-2M_z)$$