#### From solid to quantum liquid



## fractionalization





by Alexander Tsirlin, Leipzig University

Lecture 23: January 28, 2025

Advanced Solid-State Physics, WS 24/25

From solid to quantum liquid

## Antiferromagnet: two sublattices



#### Spin waves: ferromagnet vs. antiferromagnet



J. Appl. Phys. 39, 383 (1968) and Phys. Rev. Lett. 23, 1394 (1969)

#### Staggered magnetization



J. Magn. Magn. Mater. 555, 169302 (2022); Phys. Rev. B 104, 094428 (2021)

### Staggered magnetization



J. Magn. Magn. Mater. 555, 169302 (2022); Phys. Rev. B 104, 094428 (2021)

# Magnon decay

#### Scattering intensity (a.u.)



Material: copper formate ( $S = \frac{1}{2}$  on a square lattice) magnon breakdown near zone boundary

Nature Phys. 11, 62 (2015)

Magnon decay



 $S = \frac{1}{2}$  on a triangular lattice: large non-linear corrections and magnon breakdown

#### 2D magnet





Spin flip creates two domain walls

Nature Phys. 9, 435 (2013)



Spin flip creates two domain walls



These walls propagate independently

Nature Phys. 9, 435 (2013)

#### Fractionalization: energy spectrum



Excitations of a spin chain are spinons (fermions)

