Study of Artificial Spin Ice In Intermediate Lattices Between Kagome and Triangular Configurations

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Abstract

The exotic behavior of Artificial Spin Ice (ASI) and its potential in technological applications offer significant opportunities for exploring various physical phenomena. With Kagome and Triangular ASIs as bases, a wide variety of subnetworks between them can be obtained, noting that both have the same spatial geometry. Considering this, this work presents a Monte Carlo simulation study of some of these subnetworks, aiming to obtain their distinct characteristics and understand how they evolve into different configurations. Our results demonstrate how the influence of emerging excitations affects the physical properties of these systems, as well as how the use of the Magnetic Spin Structure Factor (MSSF) can be useful in revealing the charge and spin ordering in the system.

Model and Methodology

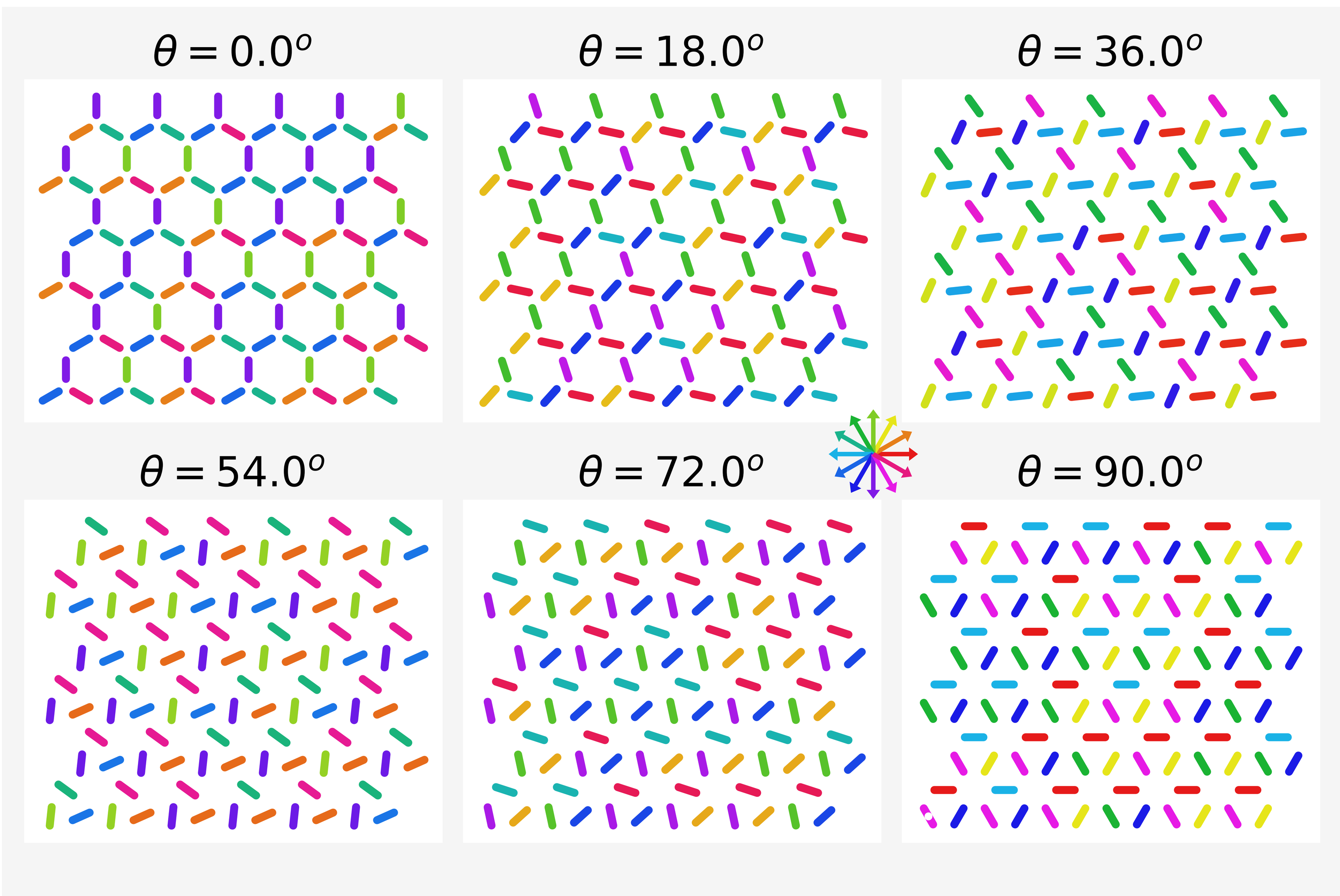

Figure 1: *Some initial settings for different systems. Images generated using [3]*

- Model Hamiltonian:

$$\mathcal{H} = D\sum_{i,j}\left[\frac{\vec{S}_i\cdot\vec{S}_j}{r_{ij}^3} - \frac{3(\vec{S}_i\cdot\vec{r}_{ij})(\vec{S}_j\cdot\vec{r}_{ij})}{r_{ij}^5}\right]$$

- Specific Heat:

$$Cv = \frac{<E^2> - <E>^2}{Nk_BT^2}$$

- Magnetic Spin Structure Factor:

$$\mathcal{I}(\vec{q}) = \frac{1}{N}\sum_{i=1}^{N}\sum_{j=1}^{N}\vec{S}_i^{\perp}\cdot\vec{S}_j^{\perp}e^{i\vec{q}\cdot(\vec{r}_i-\vec{r}_j)}$$

Results and Discussions

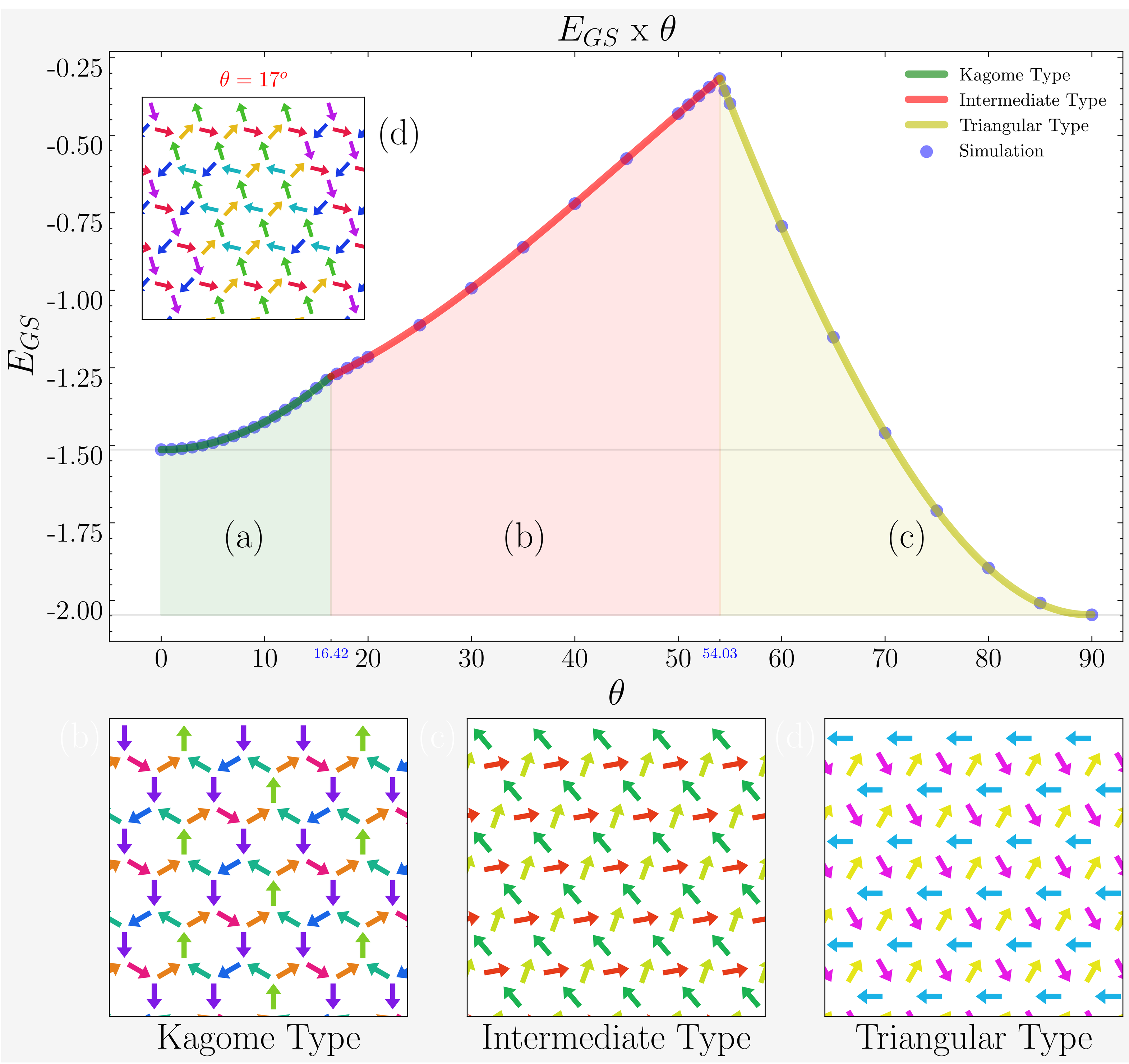

Figure 2: *Ground-state energy as a function of spin angle. We observe three different base configurations for the spin direction. In (d), we observe an arrangement that does not fit into any of the other three observed.*

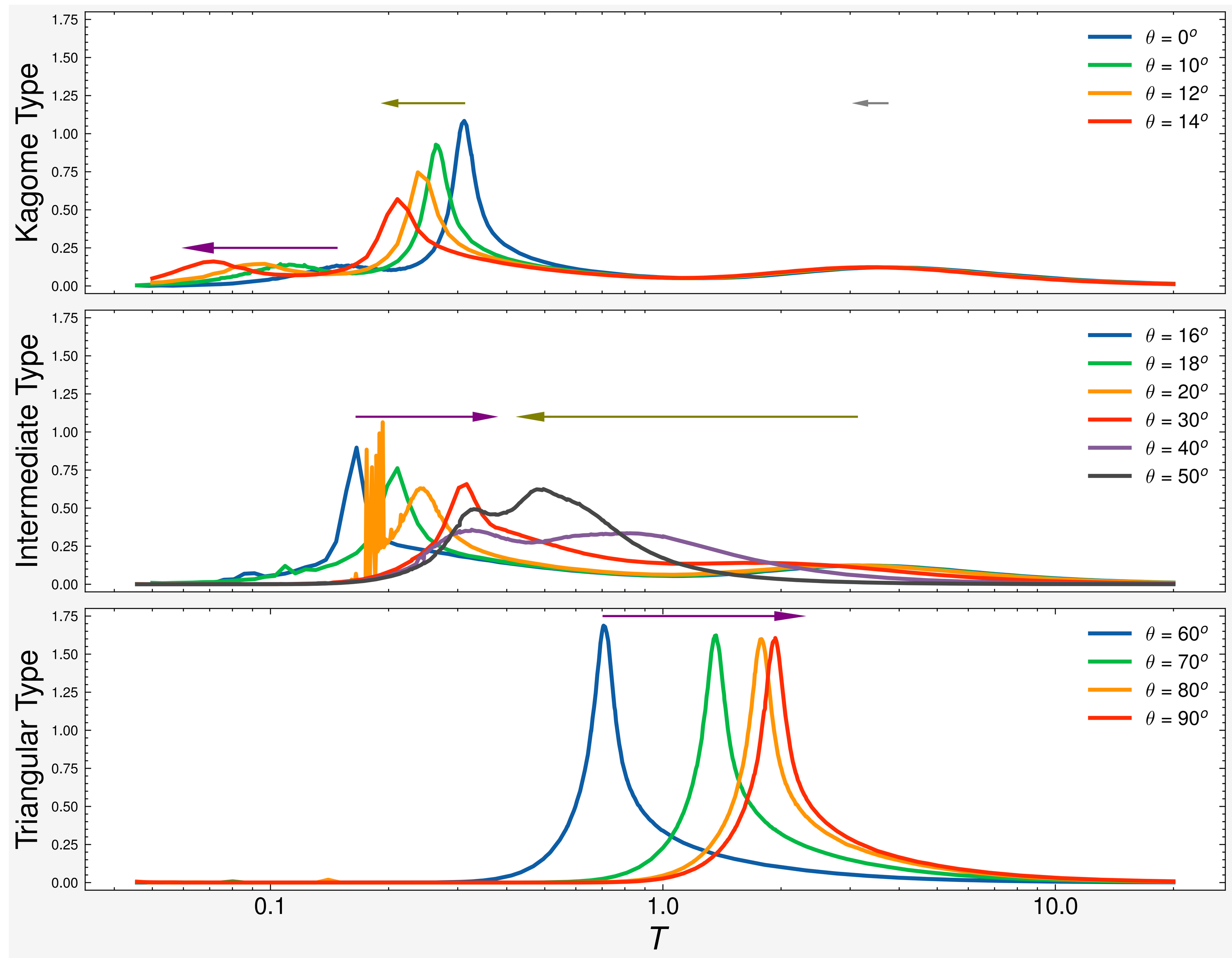

Figure 3: *Specific Heat for different systems separated by types of ground state configurations. Note that at $\theta = 20^o$ there is a possible first-order phase transition, which we did not investigate in this work.*

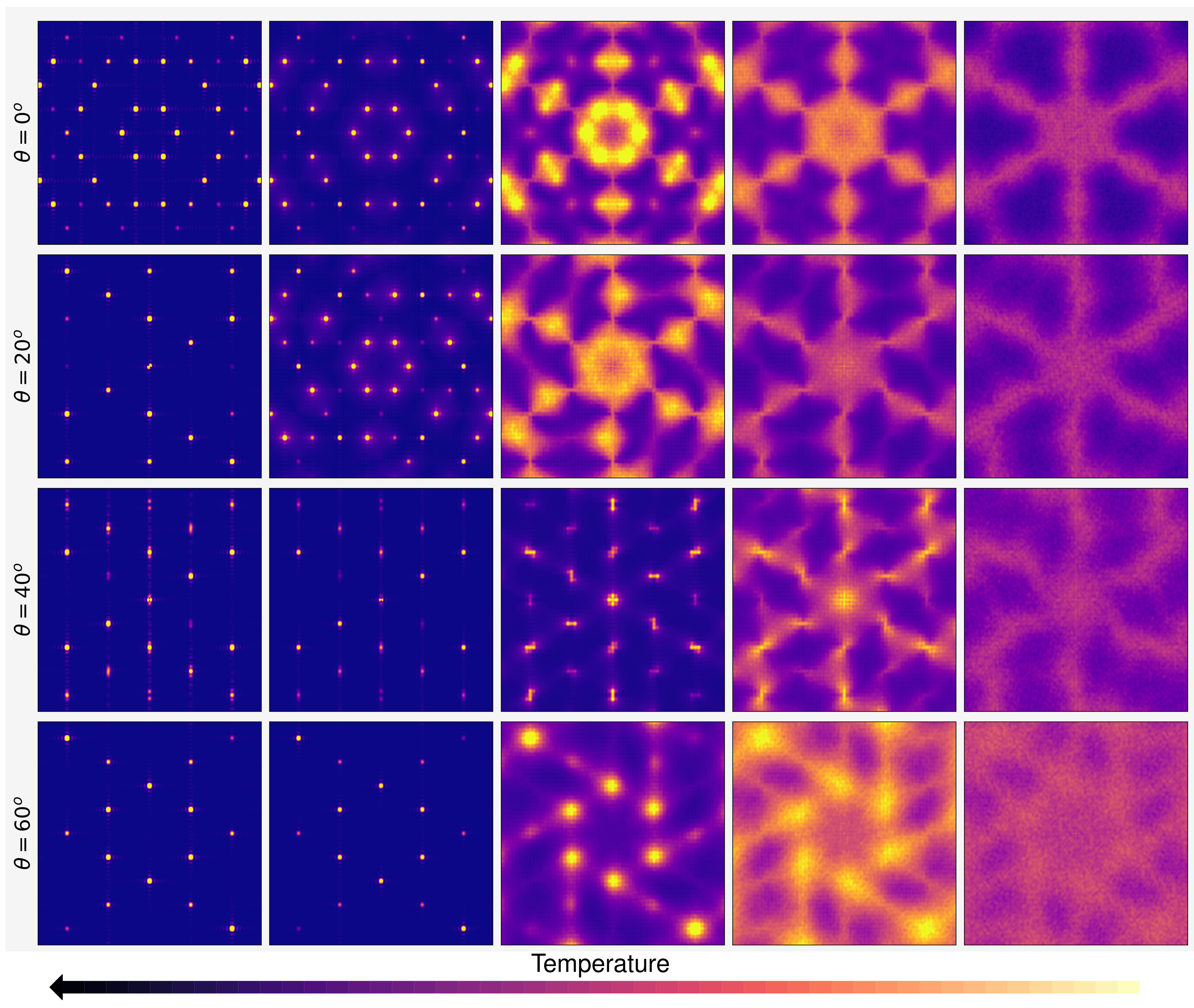

Figure 4: *Magnetic Spin Structure Factor Maps for some systems at different temperatures.*

References

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Acknowledgments

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FAPEMIG

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For more graphs!!