

ISSN : 2085-9872

JURNAL SAINS DASAR

Jurnal Nasional memuat Kajian Teoritik, Review dan hasil Penelitian dari Semua Aspek Sains Dasar (Matematika, Kimia, Fisika, dan Biologi)

$$\frac{\pi r^2}{V H^2} \int_0^{\infty} (z)$$

$$\frac{\pi r^2}{V H^2} \left[\frac{z^4}{4} - \frac{2z^3}{3} \right]$$

Sains Dasar

Vol. 2

No. 2

Hal. 1 - 109

Oktober 2013

Dewan Redaksi

- Pengarah* : Dr. Hartono
Dr. Suyanta
- Ketua* : Dr. Ariswan
E-mail: ariswan@uny.ac.id
Jurdik Fisika, FMIPA, Universitas Negeri Yogyakarta (UNY)
Kampus Karangmalang, Sleman, DI Yogyakarta, 55281
tel./fax. (0274) 548203
- Anggota* : Dr. Cahyorini K
Dr. Tien Aminatun
Atmini Dhoruri, M.Si
Agus Purwanto, M.Sc
Dr. Hari Sutrisno
Wipsar Sunu Brams Dwandaru, M.Sc, Ph.D
Prof. Dr. IGP Surya Darma
Dr. Agus Maman Abadi

Tata Usaha dan Keuangan:

Galuh Titisari, S.Si
Mega Yuniati P, S. Kom
Fajar Dwi Wijayanto, S.E
Drs. Abdulgani

Tujuan dan Ruang Lingkup

Jurnal Sains Dasar (J. Sains Dasar) adalah jurnal nasional yang memuat kajian teoritik, review dan hasil penelitian dari semua aspek sains dasar yang meliputi Matematika, Kimia, Fisika dan Biologi dalam Bahasa Indonesia atau Bahasa Inggris. Jurnal Sains Dasar diterbitkan 2 kali pertahun di bulan April dan Oktober oleh Fakultas Matematika dan Ilmu Pengetahuan Alam (FMIPA), Universitas Negeri Yogyakarta (UNY).

Alamat Redaksi:

Kantor Jurnal Sains Dasar, FMIPA, Universitas Negeri Yogyakarta (UNY)
Kampus Karangmalang, Sleman, DI Yogyakarta, 55281 tel./fax. (0274) 548203
e-mail: ariswan@uny.ac.id

Penerbit:

Fakultas Matematika dan Ilmu Pengetahuan Alam (FMIPA),
Universitas Negeri Yogyakarta (UNY)

DAFTAR ISI

Kajian efek Mpemba pada pendinginan air keran yang awalnya dipanaskan secara infinitesimal (Elisabeth Pratidhina Founda Noviani, Arif Setiawan, dan Wipar Sunu Brams Dwandaru)	1
Pola adsorpsi pewarna azo oleh biosorben dari kulit pisang (Endang Widjajanti LFX, Marfuatun, dan Dewi Yuanita)	8
Pengaruh pemberian ekstrak herba meniran (<i>phyllanthus niruri</i>, l.) terhadap ukuran dan struktur histologik kelenjar prostat tikus jantan (<i>rattus norvegicus</i>, l.) (Ciptono dan Tri Harjana)	17
A study of frustrated system in 2 dimensional triangular lattice antiferromagnet using the Ising model (Noor Rika Safitri, Aini Rahmatun Umami Fadlillah, Denny Darmawan and Yosi Aprian Sari)	26
Bifurkasi <i>pitchfork</i> pada sistem <i>flutter</i> sayap pesawat terbang (Hartono dan Kus Prihantoso Krisnawan)	31
Finding the optimum curvature strains and elasticity constant K_4 for nematic liquid crystals using minimization of the Frank-Oseen free energy density functional (Supardi)	36
Eksistensi dan ketunggalan solusi persamaan panas (Eminugroho Ratna Sari, Dwi Lestari, dan Fitriana Yuli Saptaningtyas)	41
Evaluasi kualitas semen pejantan sapi PO Kebumen di Kabupaten Kebumen Provinsi Jawa Tengah (Lukman Affandhy, Yudi Adinata, dan Aryogi)	49
Versi fuzzy teorema utama homomorfisma grup (Karyati dan Dhoriva Urwatul Wutsqa)	56
Pengaruh jumlah lilitan dan diameter kawat terhadap suseptibilitas magnet udara bersuhu sangat rendah dari 157 K – 253 K (M. Toifur)	65
Pengaruh suhu dan waktu proses terhadap karakter biodiesel hasil sintesa dari minyak biji ketapang (Endang Dwi Siswani, Susila Kristianingrum, Siti Marwati, Arief Noviantara dan Rosa Yuniastuti)	72
Uji aktivitas antioksidan modifikasi senyawa khrisin dengan gugus alkoksi menggunakan metode RM1 (Fadhilina Khoirun Nisa, Kasmui dan Harjito)	80

A study of frustrated system in 2 dimensional triangular lattice antiferromagnet using the Ising model

(Studi sistem terfrustasi pada antiferromagnet dengan kekisi segitiga 2 dimensi menggunakan model Ising)

Noor Rika Safitri^{1,2*}, Aini Rahmatun Umami Fadlilah², Denny Darmawan² and Yosi Aprian Sari²

¹*Department of Physics, Faculty of Science and Mathematics, Universiti Pendidikan Sultan Idris, 35900 Tanjung Malim, Perak, Malaysia, and email: rikanooors@yahoo.com*

²*Department of Physics Education, Faculty of Mathematics and Natural Sciences, Yogyakarta State University, Kampus Karangmalang, Sleman, DI Yogyakarta 55281, Indonesia
tel. 08122753549, faks. (0274) 548203 email: darmawan@uny.ac.id*

Abstract

This research was aimed to simulate the ground state and magnetization of antiferromagnet under the influence of temperature and competing interaction. The effect of competing interaction to phase transition was also investigated. The competition occurred between the nearest neighbour interaction and the next nearest neighbour interaction in the triangular lattice. The simulation was done using the 2 dimensions Ising model with Monte Carlo method combined with Metropolis algorithm.

The results showed that the ground state energy increased significantly at the critical temperature (Neel's temperature). When the competing interaction increased, the ground state energy of the lowest temperature decreased. Based on the magnetization, due to the increase of the competing interactions, the phase transition from antiferromagnet to paramagnet occurred at a higher Neel's temperature.

Key words: antiferromagnet, Ising model, competing interaction, Neel's temperature

Abstrak

Tujuan dari penelitian ini adalah melakukan simulasi terhadap energi keadaan dasar (*ground state*) dan magnetisasi untuk sistem antiferromagnet yang dipengaruhi oleh suhu dan kompetisi interaksi. Efek dari kompetisi interaksi terhadap transisi fase juga dipelajari. Dalam penelitian ini, interaksi terjadi antara tetangga terdekat dan tetangga terdekat berikutnya pada titik-titik kekisi berbentuk segitiga. Simulasi dilakukan menggunakan model Ising dua dimensi menggunakan metode Monte Carlo yang dikombinasikan dengan algoritma Metropolis.

Hasil penelitian ini menunjukkan bahwa energi keadaan dasar meningkat secara signifikan pada suhu kritis (suhu Neel). Jika kompetisi interaksi diperbesar, energi keadaan dasar pada suhu terendah akan berkurang. Berdasarkan magnetisasinya, akibat interaksi kompetisi ini, transisi fase dari fase antiferromagnet menuju fase paramagnet terjadi pada suhu Neel yang lebih tinggi.

Kata kunci: antiferromagnet, model Ising, kompetisi interaksi, suhu Neel

Introduction

Recently, geometrically frustrated spin systems are attracting considerably many researchers due to their unique properties at low temperature. These geometrical frustrations produce a high degeneracy of ground state [1]. Magnetic frustration is a system in which the localized magnetic moments (or spins) interact through exchange interaction. However, the lattice system gives challenge to the interaction in order to form the lowest ground state. The various possible interactions lead to various ground states [2]. Some materials have different exchange interaction constant (J). This difference in J value can be obtained in triangular and square lattices, which is the simplest frustration case. Due to the energy in the system, depending on the order in microscopic levels, frustration causes disorder and leads to spin glass [3]. In this frustrated antiferromagnetic system, temperature plays an important role. Temperature determines how the magnetization approaches zero value in higher dimensions (2 or 3 dimensions) [4]. Studies of frustration in antiferromagnet are done by many researchers using various model. In the Ising model, when the system is heated, the spin will flip to up or down state; hence by using this model, the study is simpler compared to the other models [3-6].

In this study, simulation was done under the influence of temperature and competing J on the ground state and magnetization. The triangular lattice with 6 x 6 lattice points is used along with Monte Carlo method combined with Metropolis algorithm in order to understand the frustrated phenomena.

Research Method

Ising model was initially invented to solve the one dimension (1D) ferromagnetic system but failed to investigate the phase transition in

the system [7]. Onsanger then extended this model to a higher dimension and showed the existence of a phase transition. In Ising model, the spin is determined as up ($\sigma = +1$) or down ($\sigma = -1$). Hence for the frustrated antiferromagnet, the Hamiltonian can be described as:

$$E = -J_1 \sum \sigma_i \sigma_j - J_2 \sum \sigma_k \sigma_l. \quad (1)$$

Using the Ising model, a study of frustrated antiferromagnet can be done via Monte Carlo method combined with Metropolis algorithm. Initially, the spin was selected randomly from the N -lattice points then flipped. This condition produces a new energy. If the new energy is lower than the previous, then the flipping process will be accepted, otherwise the probability of acceptance must be considered. If the obtained random number is smaller than the Boltzman factor obtained from the energy difference calculation, then the new energy will also be accepted. Otherwise, the initial condition is preferred.

This simulation was done on triangular lattice with 6 x 6 lattice points including the boundary condition. The parameters in this study are temperature and exchange interaction ratio (J_2/J_1) of 0.0, 0.3, 0.5, 1.0, and 2.0.

Result and Discussion

Fig. 1 shows magnetization of frustrated antiferromagnet in a triangular lattice. Without any competing interaction, the magnetization of the system is maintained at zero. By adding the interacting competition, magnetization of antiferromagnetic system is initially non-zero, but then drops to zero at some critical temperature. The magnetization drops at higher temperature as exchange interaction ratio is increased. The magnetization disappearance indicates that a phase transition from antiferromagnet to paramagnet has occurred.

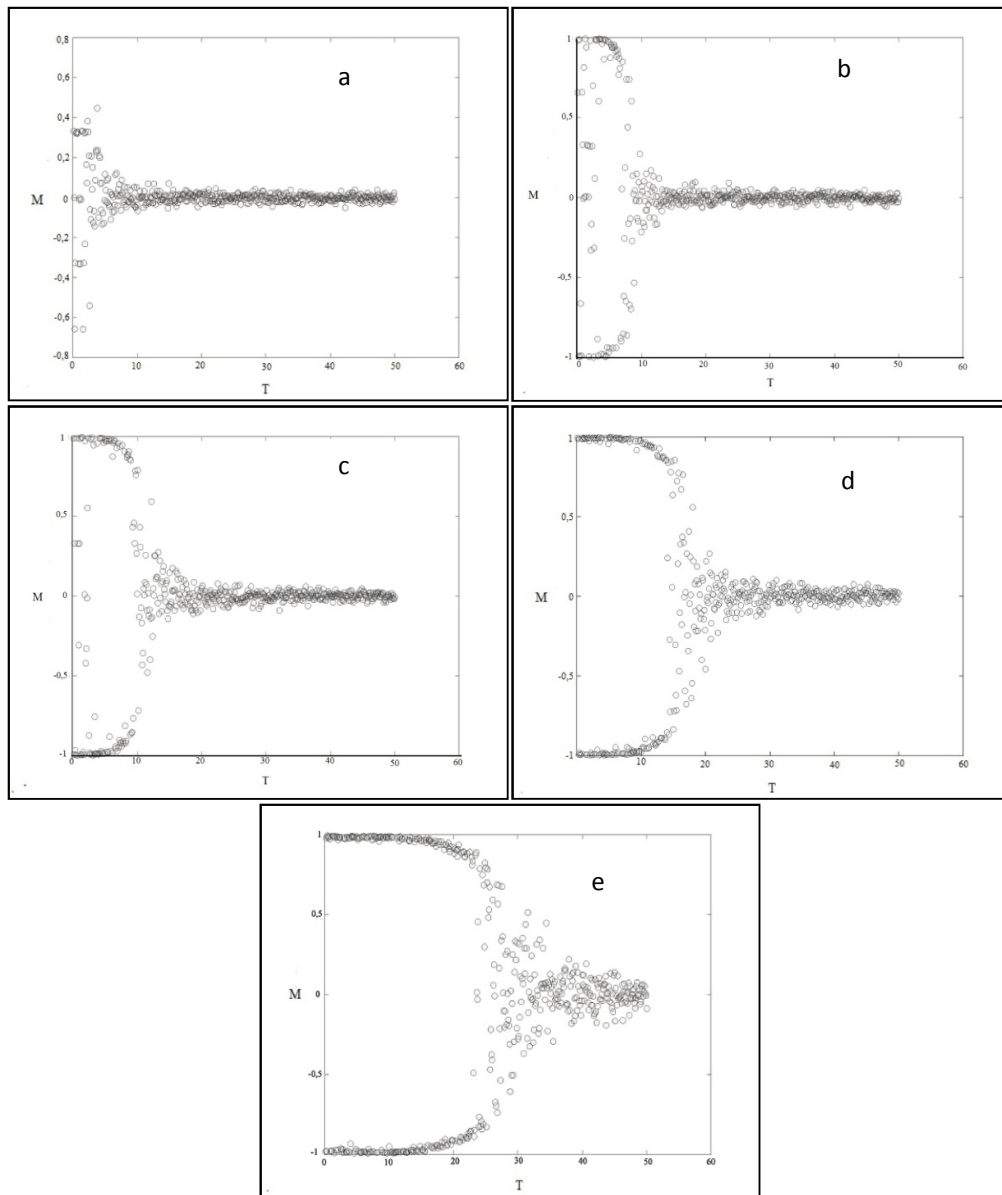


Figure 1. Magnetization of frustrated antiferromagnet with J_2/J_1 of (a) 0.0, (b) 0.3, (c) 0.5, (d) 1.0, and (e) 2.0.

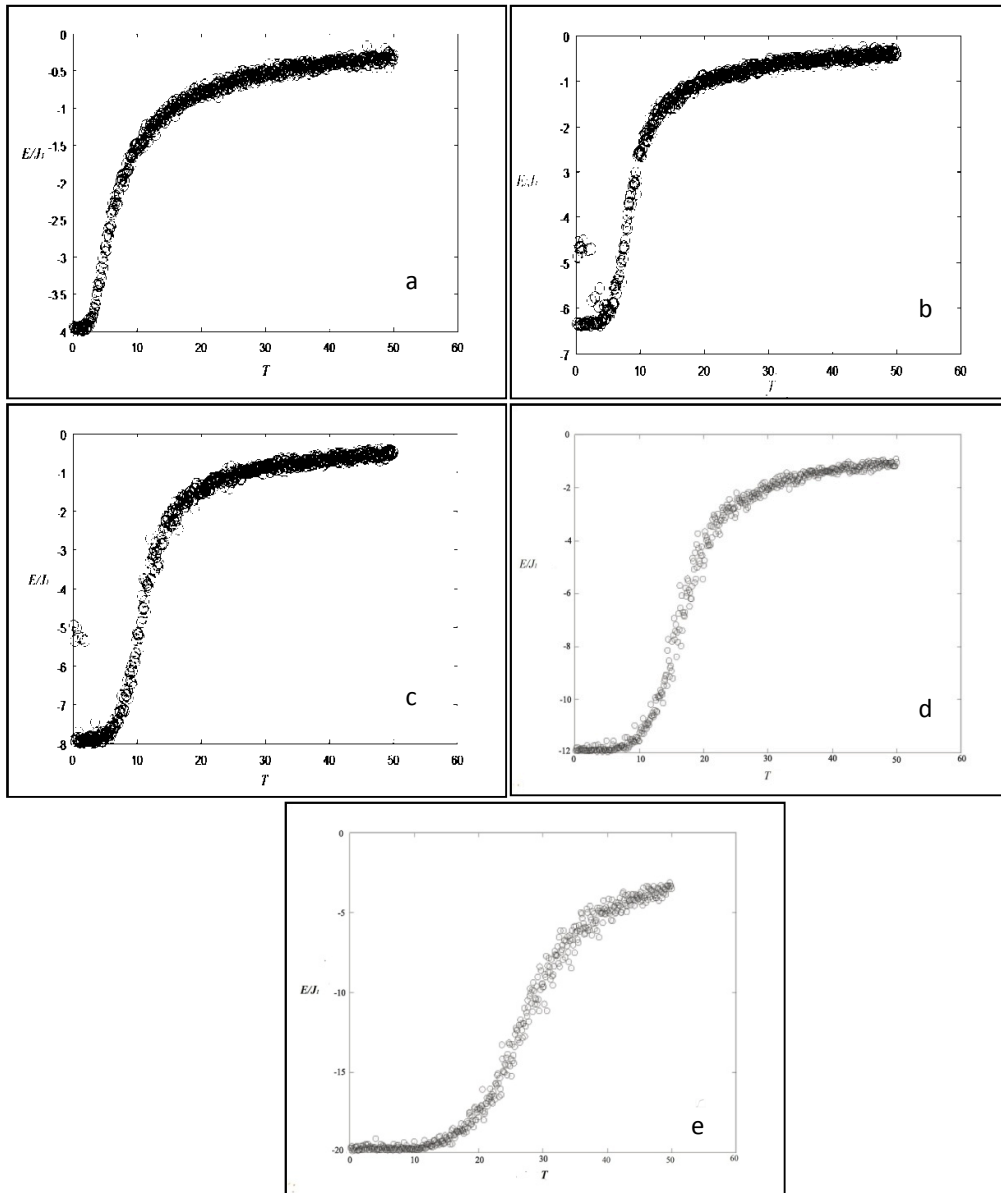


Figure 2. Energy of frustrated antiferromagnet with J_2/J_1 of (a) 0.0, (b) 0.3, (c) 0.5, (d) 1.0, and (e) 2.0.

The temperature dependence of energy is presented in Fig 2. At lower temperature, the energy of the system is constant. Then at the critical temperature, the energy is increased significantly. This critical temperature is called Neel's temperature. At Neel's temperature, many spins are flipped so that the energy is increased dramatically. This unique feature continues until some temperature point where the increase in energy is not significantly observed. From this figure, it can be suggested

that there is a phase transition from antiferromagnet to paramagnet as explained before. Interestingly, the increase of J_2/J_1 produces higher Neel's temperature. This also suggests that the interacting competition acts as a system ordering regulator. As the competing interaction ratio increases, the system ordering regulator also increases. Therefore, higher energy is needed to influence the system.

Conclusion

The ground state of a frustrated antiferromagnetic system is affected by temperature. At Neel's temperature the energy of the system is increased significantly, which indicates that the system undergoes a phase transition from antiferromagnet to paramagnet. The competing interaction also affects the energy of the system. As the competing interaction ratio increases, the initial energy becomes smaller, and the phase transition occurs at a higher temperature.

Acknowledgment

The author would like to thank Yogyakarta State University for instrumental supports.

References

- [1] M. Žukovič, et. al.: *Phys. Lett.* vol. 376 (2012): p. 1731.
- [2] Klevets, P.N., et.al.: *Journal of Magnetism and Magnetic Materials*, vol. 330 (2013): p.91.
- [3] Takengny, F.S., et al.: *The African Review of Physics*, vol. 7 (2012).
- [4] Olivi-Tran, N., et.al: *Adv. Studies Theor. Phys.* Vol. 3(2012): p. 481-488.
- [5] Fishman, R.S., et.al.: *Physical Review B.* vol. 84(2011): p. 052405.
- [6] Wang, X.Z., et.al.: *Physical Review Letters*, vol. 78(1997): p. 413.
- [7] Ising, E., A.: *Z. Phys*, vol. 31(1925): p. 253-258.