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Neutrosophy applied in Physics: Extension from Half-Ice Half-Fire Material State and Phase to Partial-Ice Partial-Fire Material State and Phase

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Abstract: The recent groundbreaking discovery of a 'Half-Ice, Half-Fire' phase of matter at Brookhaven National Laboratory, by W. Yin & A. M. Tsvelik [3], has unveiled an intriguing new dimension in condensed matter physics. This novel state, characterized by a unique coexistence of ordered 'cold' spins and disordered 'hot' spins within a ferrimagnetic material, challenges our conventional understanding of phase transitions. This short note explores the implications of this discovery through the lens of neutrosophy and neutrosophic physics, and extends the concept to a more nuanced 'Partial-Ice, Partial-Fire' state, demonstrating the potential for richer, more complex interpretations of physical phenomena.

Keywords: Neutrosophy; Neutrosophic Physics; Neutrosophic Logic; Neutrosophic Sets; Indeterminacy; Thermodynamics; Condensed Matter Physics; Spintronics; Quantum Computing; Materials Science; Half-Ice, Half-Fire; Partial-Ice, Partial-Fire; Ferrimagnet; Electron Spins; Phase Transition.

1. Introduction

Neutrosophy [1] posits that any idea or entity (A) coexists with its opposite (antiA), and a neutral (neutA) component that is neither A nor antiA. Neutrosophic logic proposes this triadic structure, accounting for degrees of truth, falsehood, and indeterminacy. Applied to physics, this yields neutrosophic physics [2] — a paradigm capable of describing phenomena imbued with uncertainty, ambiguity, or dual nature.

The 'Half-Ice, Half-Fire' [3] state exemplifies this paradigm. In this ferrimagnetic state, 'ice' denotes spin order and low entropy, while 'fire' signifies spin disorder and high entropy. These coexisting states mirror the neutrosophic framework: A ('ice'), antiA ('fire'), and neutA (indeterminate co-presence of 'ice' and 'fire').

1.1. Partial-Ice State

This state can be thought of as a system where water exists in a mixed state of solid (ice) and liquid (water). The properties of this state can vary, exhibiting characteristics of both phases depending on the temperature and pressure conditions.

1.2. Partial-Fire State

Similarly, this could represent a state where a material exhibits both combustion (fire) and non-combustion properties. This might occur in certain chemical reactions or materials that are on the verge of ignition.

2. Implications

2.1. Thermodynamic Properties

In a neutrosophic context, these states could be characterized by non-binary properties, such as temperature not being a single value but a range that reflects the coexistence of phases. For instance, the latent heat of fusion could be represented as a neutrosophic quantity, where the exact state is not fully defined.

2.2. Physical Behavior

Materials in these states might display behaviors that are not easily categorized. For example, a partial-ice state might have a varying density and thermal conductivity that changes with the proportion of ice to water.

2.3. Applications

Understanding these mixed states could have implications in materials science, particularly in the development of new materials that can exist in transitional phases, such as phase-change materials used in thermal management systems.

3. From 'Half-Ice, Half-Fire' to 'Partial-Ice, Partial-Fire'

The 'Half-Ice, Half-Fire' state, discovered at Brookhaven National Laboratory, represents a groundbreaking phenomenon in condensed matter physics, wherein two subsystems of atomic spins within a ferrimagnetic material exhibit radically different behaviors simultaneously under the same temperature. One group of spins becomes highly ordered, behaving as if in a frozen, low-energy state ('ice'), while the other remains fully disordered, fluctuating chaotically like in a high-temperature, thermally agitated state ('fire').

This coexistence of magnetic order and disorder within a single material and thermal condition defies traditional thermodynamic expectations, which typically predict uniform responses to temperature changes. The phenomenon arises from a quantum-level interaction between the spin subsystems: one resists thermal agitation and locks into an ordered configuration, while the other becomes dynamically unstable.

This paradoxical behavior not only introduces a novel state of matter but also calls for new interpretative frameworks — such as neutrosophic logic — that can account for the simultaneous presence of opposites and indeterminacy within physical systems.

As such, the 'Half-Ice, Half-Fire' state opens exciting possibilities for material science, especially in fields that require precise control over quantum or magnetic states, such as spintronics and quantum computing.

The "half-ice, half-fire" phase of matter provides a physical example of this:

- "Ice" can be seen as representing a state of order (a form of "truth" or certainty).
- "Fire" can be seen as a state of disorder (a form of "falsehood" or uncertainty).
- The fact that they coexist demonstrates a "neutral" or "indeterminate" state, where both opposing characteristics are present.

Therefore, this physical phenomenon, provides a real world example of the theoretical neutrosophic concepts. It shows that in physics, like in philosophy, that there are states of being that contain opposing characteristics.

4. Bridge between Philosophy and Science

4.1. Coexistence of Opposites

- *Half-ice, half-fire*: Physical manifestation of two opposing phases.
- *Neutrosophy*: Intellectual framework for understanding how opposites and neutralities coexist.

4.2. Indeterminacy

- The physical system is not completely one thing or the other — there is a *superposition* or a *dynamic balance*.
- Neutrosophy embraces this *indeterminacy (I)* as a fundamental component of reality and truth.

4.3. Beyond Binary

- Classical physics wants systems to be one phase or another.

Neutrosophy, like quantum mechanics, accepts *contradiction* and *non-binariness* — and gives it a structured language.

5. Neutrosophic Interpretation

We propose an extension from the discrete notion of 'half' to a continuous range, i.e. 'partial': 'partial ice, partial fire'. This allows the modeling of hybrid states via degrees of membership in ice-like or fire-like behavior, see *Figure 1*.

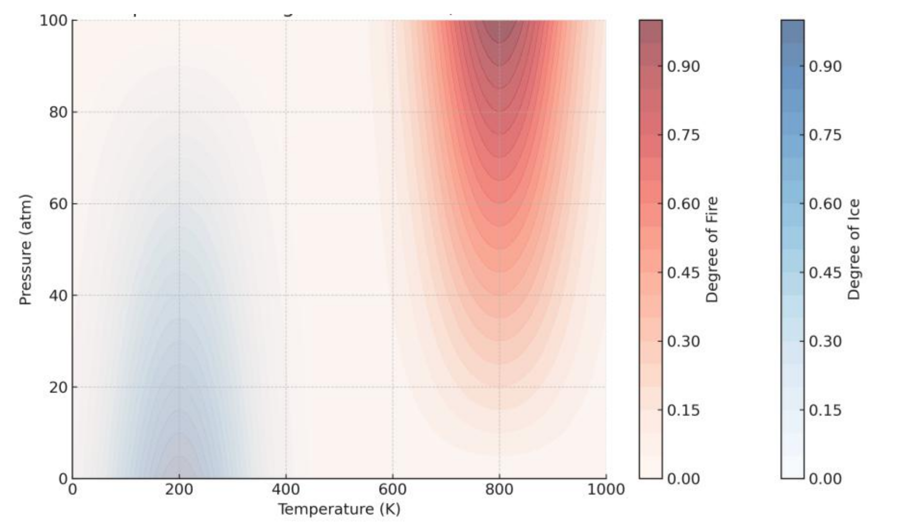

Figure 1. Neutrosophic phase diagram showing degrees of ice (blue) and fire (red) as functions of temperature and pressure.

Such degrees are not binary but exist on a spectrum, best captured by neutrosophic sets I_x, F_x, and N_x, denoting the degrees of ice, fire, and indeterminacy respectively, see *Figure 2*.

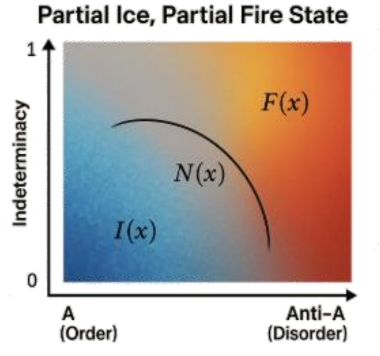

Figure 2. Spectrum of degrees captured by neutrosophic sets: I(x), F(x), and N(x).

Therefore, using neutrosophic sets and logic, we define:

I_x: Degree of membership in the 'ice' state,

F_x: Degree of membership in the 'fire' state,

N_x: Degree of indeterminacy,

where $0 \le I_x + F_x + N_x \le 3$.

6. State of Matter vs. Phase of Matter

The terms 'state of matter and 'phase of matter' are often used interchangeably in everyday language, but in physics and material science, they refer to distinct concepts.

A state of matter refers to the broad categories that describe the general physical form of a substance, based on the arrangement and energy of its constituent particles. The classical states are solid, liquid, gas, and plasma, and more recently, exotic states such as Bose–Einstein condensates, quark-gluon plasma, and half-ice, half-fire states have also been recognized. Each state is characterized by a particular degree of particle freedom, density, compressibility, and energy distribution.

A phase, on the other hand, refers to a distinct and homogeneous region within a material that has uniform physical and chemical properties, such as density, magnetization, or crystal structure. A single state of matter can include multiple phases.

For example, within the solid state, ice and dry ice (solid CO_2) are distinct phases due to differences in molecular structure and composition. Similarly, within a liquid state, oil and water form two immiscible phases because they do not mix, despite both being liquids.

7. Examples

A common and intuitive example is *water*: In a sealed container at the melting point, water can simultaneously exist as solid (ice) and liquid (water). Both are in the same state (condensed matter), but represent two different phases with distinct structures and energy levels.

Likewise, in *alloys* or *magnetic materials*, different phases can emerge within the same state due to variations in microscopic ordering or composition, such as in ferrimagnetic systems where sublattices may exhibit contrasting spin behaviors.

Understanding this distinction is crucial when analyzing complex systems, especially those that defy classical categorizations, such as the newly observed 'half-ice, half fire' matter state, which exhibits multiple phases with contradictory characteristics within a singular state.

8. Hybrid Material States and Phases: α-Ice and β-Fire

The conceptual models of α-Ice and β-Fire are proposed to describe intermediate or hybrid material states and phases that defy classical categorizations. These terms build on the neutrosophic logic framework, allowing for continuous degrees of order and disorder, rather than discrete, mutually exclusive states.

Let α and β be real numbers in the open interval (0, 1), representing the degree to which a material exhibits ice-like (ordered) or fire-like (disordered) characteristics, respectively..

8.1. α-Ice State

An α-Ice state refers to a partially ordered configuration within a material. It may represent a mixture of crystalline and amorphous regions, or a spatial gradient between solid and liquid properties. Physically, this could correspond to conditions near a phase boundary—such as a supercooled liquid beginning to crystallize, or slush (a mixture of ice and water) in a metastable equilibrium. The value of α quantifies how "close" the system is to full solidification.

8.2. β-Fire State

A β-Fire state captures partial thermal excitation or combustion behavior. In physical systems, this might describe materials undergoing incipient ignition, chemical pre-reactions, or localized hotspots within an otherwise stable medium. In magnetism, it could reflect the partial disruption of spin order due to thermal fluctuations, as observed in the 'half-ice, half-fire' state. A β approaching 1 implies high levels of energetic disorder; conversely, a β close to 0 indicates predominantly stable or non-excited behavior.

These hybrid states are particularly valuable in modeling non-equilibrium systems, mesophases, or complex adaptive materials that display coexisting or competing behaviors across different regions or scales.

9. Practical Relevance

In *materials science*, understanding and controlling α-Ice states is crucial for phase-change materials used in memory storage and thermal regulation.

In *energy systems*, β-Fire models help describe combustion efficiency, ignition control, or partial reactions in plasma and catalytic environments.

In *spintronics*, where the control of spin order and disorder is key to information processing, this hybrid model provides a richer vocabulary for describing partially coherent quantum states.

By quantifying α and β, researchers can construct *material phase maps* that describe gradients of behavior rather than sharp boundaries, aligning well with both experimental observations and the neutrosophic logic of partial, contradictory, and uncertain realities..

10. Conclusion

Analyzing the 'Half-Ice, Half-Fire' discovery through neutrosophic principles reveals new dimensions in state and phase theories. The "half-ice, half-fire" state and phase of matter embodies the neutrosophic idea of coexisting opposites and indeterminacy. It provides a tangible example of how seemingly contradictory properties can exist simultaneously within a system. AI was partially used in this paper. Extending this interpretation to partial states and phases enhances our capacity to model hybrid phenomena, supporting advancements in materials science, thermodynamics, and information systems. Neutrosophy enables a more nuanced understanding of physical reality.

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