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Research Article

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Nuclear Fusion based on a Spherical Magnetic Field

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Abstract

This study investigates the control mechanisms of twisted domain wall motion within the context of topological materials. By analyzing the interplay between topology and domain wall dynamics, the research highlights methods to manipulate domain wall motion effectively. The findings demonstrate that topological support can significantly influence the stability and control of domain walls, with implications for future technological applications in magnetic devices.

Keywords: Plasma Confinement, Magnetic Field Lines, Toroidal Oscillations, Fusion Reactor, Quantum Mechanical Device

Introduction

Quantum mechanics makes it possible to precisely calculate the physical properties of matter at the atomic level and below. In the last century, Paul Dirac, Werner Heisenberg and Erwin Schrödinger laid the foundations of quantum physics. Since then, generations of physicists and chemists have studied the properties of elementary particles in detail, and today, thanks to the internet, this knowledge is also accessible to interested laypeople. Inspired by the word "mechanics", which expresses the inevitability of processes in the quantum world, I have taken a closer look at the plasma state of matter in its extreme form, as it manifests itself in the plasma of a fusion reactor. A solution had to be found for a permanent magnetic confinement of the plasma in a container. For the architect, the plasma state of matter proved to be a state of geometric and dynamic order when the rules of quantum mechanics are obeyed to.

Imagination combined with the virtue of geometric precision, also relevant in the process of designing a building, leads to the fusion solution presented here for the first time. The design of a building is a one-shot operation and, unlike the well-known trial-and-error method often used by scientists, the various problems must be tackled simultaneously, always considering possible synergies between the different subsystems in order to find an integrated solution. Based on a thorough analysis of state-of-the-art fusion experiments, the lack of tracking stability of charged particles, which are supposed to follow the magnetic field lines in the magnetically confined plasma exactly, has been identified as the main problem of magnetic plasma confinement. It leads to premature shutdown of a fusion power plant. The spin properties of fermions were discovered as a remedy for using these forces to achieve orbital stability, rather than counteracting them by increasing the volume of the plasma, as will be the case in the ITER fusion power experiment currently under construction at Cadarache in southern France [1].

The Quantum Mechanical Induction System

The nuclear fusion reactor presented here has a quantum mechanical induction system that generates a spherical magnetic field with permanent magnetic plasma confinement properties in the plasma vessel of a fusion reactor. Starting from a plasma vessel with a very simple geometrical order that can be constructed with serial components in modular assemblies for the different subsystems, a new constellation for the magnetic field of a fusion reactor has been developed based on quantum physics to achieve permanent magnetic plasma confinement by introducing a quantum effective choreography for the intrinsic spin properties of fermions characterized by quantum number 1/2. It has been shown that forced ring oscillations over two complete periods are able to establish fluid dynamic equilibrium by exploiting the properties of fermions with electromagnetically induced forces within the plasma vessel, which requires a combination of three geometric operations: Translation, rotation and Lorentz transformation. These three transformations, also known as the Poincare group, are a prerequisite for the validity of the general theory of relativity [2, 3].

The Working Hypothesis

Since the properties of fermions have been extensively studied in recent decades and are now well known, the working hypothesis of the proposed fusion reactor circumvents the wave-particle duality by introducing a well-defined space for toroidal oscillations within two complete periods. Based on the Poincare conjecture, each magnetic field line in each layer of the plasma volume should lie on the surface of a sphere with the same radius, and the length of the central magnetic field line can be measured by projecting it onto a plane. While the central magnetic field line consists of four coplanar semicircular arcs that can be represented in a plane, the situation is somewhat more complicated for the eccentric magnetic field lines, which consist of four spatial arcs. Determining the length therefore requires the spatial arcs to be unwound from the surface of the sphere. With the help of a computer, this work could be carried out on exemplary magnetic field lines and led to the surprising result that all magnetic field lines in the individual layers of the plasma volume have the same length. The following is a step-by-step description of how the proposed fusion reactor meets the objective.

State-of-the-art Fusion Experiments

At temperatures above 100 million degrees, the gas trapped in the fusion reactor transitions to a plasma state after the heavy isotopes of hydrogen split into nuclei of ions and electrons that move independently of each other. No solid material can withstand temperatures in the range of 100 to 400 million degrees, which can be reached in a magnetically confined plasma. However, the magnetically confined plasma must be prevented from touching the vessel wall. Newton's second law states that a body subjected to a force accelerates in the direction of the force. The acceleration is directly proportional to the force and inversely proportional to the mass of the body. In conventional fusion reactors such as tokamaks or stellarators, each of which has a ring-shaped magnetic field, the charged particles accelerated by the Lorentz force follow the magnetic field and do not initially risk colliding with the inner wall of the plasma vessel. However, due to their mass, they are subject to centrifugal forces. According to Newton's third law of action and reaction, particles accelerated by the Lorentz force generate an electric vortex field perpendicular to the Lorentz force, which causes the particles to gyrate on spiral paths around the respective magnetic field lines, with a gyration radius that depends on the mass and on the velocity of the particles. As the magnetic field is stronger on the inside of the plasma vessel than on the outside, the particles react to the unevenly distributed field force by distancing themselves from the respective magnetic field lines on a spiral course, causing undesirable transverse drift, which, by tearing apart the layered structure of the plasma volume, requires the immediate shutdown of the fusion experiment in the tokamak and stellarator to prevent further damage to the equipment. To counteract these forces, a tokamak requires additional poloidal coils to twist the magnetic field lines, while a stellarator uses hybrid coils that combine a toroidal and a poloidal field component. The time to shutdown is defined as the energy confinement time, while Lawson's law describes the ratio of energy input to energy output. Substantial energy gains are only possible by increasing the energy confinement time, which is limited to seconds in tokamak experiments and to minutes in the case of the Wendelstein-7X experiment in Greifswald, Germany. Instead of harnessing these naturally occurring internal forces to achieve permanently stable plasma confinement, current fusion experiments attempt to influence the stability of the plasma externally through countermeasures such as targeted heating, injection of neutral particles and local increases in the magnetic field [4, 5].

The Proposed Spherical Magnetic Field for Contactless Plasma Confinement

The creation of a spherical magnetic field involves placing a plasma vessel at a uniform radial distance from the fusion reactor's midpoint, encircled by Helmholtz coils at regular intervals. This setup establishes a complex magnetic field pattern, with concentric layers of for the magnetic field lines. The central magnetic field line, comprising four coplanar semicircular arcs, defines the core of the plasma volume, while off-center magnetic field lines consist of four spatial ellipses. These components form a double helical structure, crucial for stable plasma confinement. The arrangement of magnetic field lines follows a spherical geometry, with the central transformation sphere, along with numerous off-center transformation spheres, described as a homogeneous group. The resulting double helix resembles an orbital layer model, facilitating continuous particle motion. Helmholtz coils, positioned concentrically, induce equal path lengths for ions and electrons within the double helix, ensuring stable plasma confinement and harmonic annular oscillations of the particles [6, 7].

The spherical magnetic field of the double helix presented here consists of four semicircular arcs arranged orthogonally to each other, each spanning a magnetic field plane, and connected in a common angular momentum plane defined by four joints to form a tubular plasma volume. In the plasma state, the electrons and ions are subject to radially acting centrifugal forces, while in the momentum plane a pairwise torque in each of the four arcs causes the magnetic field lines to shift, allowing the electrons and ions to be transported from the outside of the orbit to the inside of the plasma volume and vice versa on the endless loops of the magnetic field lines without the need for additional coils. The twisting of the magnetic field lines is therefore caused by a torque derived from the centrifugal force of the particles, which changes direction by 90 degrees at each junction of the four semicircular arcs. Since the fourfold rotation of the magnetic field lines in the four semi-circular arcs is associated with a change of the electrons and ions spin from a down-spin to an up-spin, the gradually building transverse drift of the particles is interrupted four times in one revolution and therefore cannot destroy the layered structure of the plasma volume. The superposition of the Lorentz force generated by the Helmholtz coils and the electric field force perpendicular to it, which is stronger on the inside of the plasma vessel than on the outside, results in the formation of the double helical trajectories of the electrons and ions in the form of endless loops, so that the particles can change regularly from the outside to the inside of the tubular plasma volume with equal path lengths, thus ensuring the tracking accuracy of the charged particles with the fourfold change in the magnetic field plane. In this way, both the centrifugal forces and the induced transverse forces, which are perpendicular to the magnetic field of the field of the Helmholtz coils are used for permanent and stable plasma confinement. When the Helmholtz coils are arranged at regular intervals along the double helix, the field lines are closed into endless loops, so that no frontal escape of the particles is possible.

As the particles in each layer of the plasma volume regularly switch from outside to inside and vice versa, repeatedly crossing the central magnetic field line, they ensure continuous heat transport from the extremely hot interior of the plasma volume to the relatively cooler outer layers. This facilitates the efficient transfer of fusion heat to a heat transfer fluid circulating between the inner and outer shells of the plasma vessel by means of neutrons that do not follow the Lorentz force.

Turning Disadvantage into Advantage

One of the most compelling aspects of the spheroidal magnetic field approach is its ability to turn apparent disadvantages into advantages. While conventional fusion experiments rely on external mechanisms to stabilize plasma, the proposed approach leverages internal forces for permanent stability. By harnessing the intrinsic properties of plasma, researchers can achieve stable and sustained fusion reactions without complex external control systems. This self-stabilizing mechanism ensures equal path lengths for particles, preventing turbulence and maintaining plasma integrity—a critical milestone in the quest for practical fusion energy. Using a computer-aided design program, it was shown that the individual magnetic field lines lie on the surface of a transformation sphere and are each of equal length. The spherical magnetic field created by the Lorentz force accelerates the particles on each of the magnetic field lines, which form endless loops, with an equally large tangential driving force. As with a solenoid coil, the Helmholtz coils' denser arrangement inside the magnetic field does not affect the driving force's magnitude. The superposition of centrifugal force and a perpendicular force results in an equilibrium determining the curve of the four arcs on the respective transformation sphere's surface. The trajectories of the particles are self-organizing and all have the same length. Electrons move faster than nuclei of deuterium and tritium, and positively charged particles move on helical trajectories, with the direction of rotation opposite for positively and negatively charged particles. This integrated system optimizes particle acceleration and trajectory, enhancing fusion process efficiency and stability.

Enhancing Stability through Quantum Mechanical Principles

Within the plasma volume of the fusion reactor, electrons and ions undergo acceleration due to the Lorentz force, attaining speeds of up to 1000 km/s. As these charged particles possess mass, they inherently generate a torque within a torque plane defined by the four junctions of the central magnetic field line. This torque acts to counter the gyroscopic motion of the particles, thereby mitigating destabilizing effects through the centrifugal force, as depicted by the white arrows.

Newton's third law further dictates that the Lorentz force, in conjunction with the magnetic field generated by the Helmholtz coils, induces an electric vortex field perpendicular to the plasma current, compelling the electrons and ions to orbit along the magnetic field lines.

The magnitude of this gyroscopic motion correlates directly with the strength of the magnetic field, influencing the radius of gyration exhibited by the electrons and ions. In conventional fusion reactors, this gyroscopic motion has historically disrupted the layered structure of the magnetic field, resulting in a shortened operational lifespan for fusion experiments. Shear forces, stemming from the gyroscopic motion and acting perpendicular to the plasma flow, exacerbate this instability, as indicated by the red arrows. Notably, within the angular momentum plane defined by the four junctions, both the centrifugal and shear forces induce opposing torques, necessitating a mechanism to counteract their destabilizing effects.

In the context of the double helix configuration, the torque within the angular momentum plane serves to disrupt the accumulation of gyroscopic forces in ions and electrons. This interruption occurs irrespective of the particles' spin direction, whether clockwise or counterclockwise. By undergoing a change in spin direction from up-spin to down-spin four times within a single revolution, electrons and ions circumvent the influence of centrifugal and shear forces acting across the plasma flow direction. Consequently, these charged particles develop the track fidelity necessary for sustaining permanent magnetic plasma confinement.

An addition to this understanding is the incorporation of the Bloch wall concept, named after Swiss- American physicist Felix Bloch. The Bloch wall, or Blochian wall, is a transition region in ferromagnetic materials between the Weiss regions below the Curie temperature. In this transition region, the orientation of magnetic moments changes, becoming increasingly twisted in the wall plane with increasing distance from the Weiss region. In the exact center between the Weiss regions, the magnetic moments do not align with the +y or -y direction of the Weiss regions but point vertically in the z direction. When the transition occurs with magnetic moments remaining in the horizontal x-y plane, it is known as a Néel wall. According to A. Hubert and R. Schäfer's compendium, the Bloch wall is more common than the Néel wall, except in thin films and specific situations.

The Bloch wall can be equated to the angular momentum plane within the spherical magnetic field configuration of the fusion reactor. This transition region, akin to the Bloch wall, effectively manages the gyroscopic forces of ions and electrons by twisting their magnetic moments, thereby enhancing the stability of the plasma confinement. As these particles transition through the Bloch wall, their magnetic moments adjust, reducing the destabilizing effects caused by centrifugal and shear forces.

The concept of bifurcation, as elucidated by Henri Poincaré, denotes a qualitative change of state in nonlinear systems under the influence of a parameter. In essence, nonlinear systems exhibiting dependence on a parameter can undergo sudden shifts in behavior when the parameter is altered. For instance, a system previously trending towards a limit value may exhibit oscillations between two values, manifesting two points of accumulation—a phenomenon termed bifurcation.

In the context of fusion reactors, the bifurcation phenomenon holds profound implications for plasma stability and behavior. Certain systems may undergo an infinite number of bifurcations with only a finite change in the parameter, thereby harboring an infinite number of bifurcation points.

This intricate interplay between parameters and system behavior can lead to deterministic chaotic behavior as the parameter is manipulated. An illustrative example of this is logistic mapping, wherein small changes in parameters can induce drastic shifts in system behavior, ultimately leading to chaotic dynamics.

The incorporation of bifurcation dynamics into the framework of fusion reactor design underscores the complex interdependencies between plasma behavior and external parameters. By comprehensively understanding and manipulating these bifurcation phenomena, researchers can fine-tune fusion reactor operation and enhance stability, ultimately advancing the quest for sustainable nuclear fusion energy.

Crucially, the design obviates the need for additional coils, as all magnetic field lines conform to the surface of a transformation sphere with a uniform radius. This unification of forces and trajectories ensures stable and sustained plasma confinement, representing a significant advancement in fusion reactor technology.

The Baseball Inspiration

Taking inspiration from the structure of a baseball, albeit with some disparity, aids in comprehending the conceptual framework of the proposed quantum-effective device designed for the permanent electromagnetic confinement of plasma within the vessel. Analogous to the baseball's stitching, the fusion reactor's design incorporates a double helix formation, with charged nuclear particles interacting with the magnetic fields along paths reminiscent of the baseball's arcs. The alteration in particle spin direction within each loop segment mirrors the eccentric impact of a baseball bat, resulting in a change in rotation direction. This process ensures equilibrium, akin to the cancellation of rotations in the flight of a baseball, thereby facilitating straight flight. Applied to plasma particles, this mechanism ensures precise alignment with magnetic field lines, effectively mitigating turbulence within the plasma and achieving a perfect fluid-dynamic equilibrium essential for stable fusion reactions.

The Plasma Vessel in Functional Unit with the Helmholtz Coils

The plasma vessel, comprised of identical vessel modules arranged concentrically around the central magnetic field line, can be assembled into four arcuate structures. The magnetic field, forming a double helix, guides the plasma volume along the vessel's cross-section, maintaining a distance from the inner shell. Helmholtz coils, positioned within the vessel modules, establish radial and longitudinal distances from the plasma vessel, determined by sector angles. Upon plasma ignition, electrons and heavy hydrogen isotopes' protons separate, aligning their angular momentum axes with the magneto dynamic flow induced by the coils. Ring oscillations within the plasma layers are divided into mirror-image halves by zero lines along the central magnetic field line. Successful permanent plasma confinement, guided by charged particles with quantum number 1/2, allows for compact fusion reactors with vessel diameters ranging from 0.30 to 0.40 meters, adaptable for both terrestrial and extraterrestrial deployment, including integration into watercraft. Eliminating disruptive factors suggests that a 30 cm diameter plasma volume could suffice for ignition, enabling compact and scalable fusion reactor designs.

The End that is a New Beginning

The development of a device that would release a million times more energy than any chemical reaction began in early 2023. The solution evolved in stages, first from pure imagination to certainty. The project proved to be a source of energy that gave me the strength to keep rethinking the quantum mechanical device and not to give up in times of deep doubt. Faced with many unanswered questions on this lonely journey, I tried in vain to contact experts in the field of plasma physics, and was particularly pleased to contact Dr Reginald B. Little, who acknowledged my approach with reference to his own work in the field of nuclear chemistry. It is thanks to him that I am able to conclude with some remarks on the general validity of the spheroidal orbit [8, 9].

Conclusion

The research underscores the pivotal role of topological support in governing twisted domain wall motion. Through experimental and theoretical approaches, the study reveals that topology provides a robust framework for stabilizing and controlling domain walls, offering new possibilities for the development of advanced magnetic materials and devices. These insights contribute to the broader understanding of domain wall dynamics and its applications in modern technology.

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