DeepSeek vs. ChatGPT at Advanced Levels

In Explaining Crookes Radiometers

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Introduction

Large AI models, like DeepSeek and ChatGPT, demonstrate impressive capabilities in addressing common questions, often at a level comparable to that of a PhD expert. When tackling these types of queries, both models perform similarly, making it hard to distinguish between them. This situation is similar to giving a high school physics problem to a PhD graduate and a high school student—both may provide satisfactory answers. However, the true distinction becomes apparent when the questions venture into more advanced fields. This article will assess the models' performance on cutting-edge research questions, particularly in areas where reliable knowledge is still evolving. One such example is the operation of Crookes radiometers, a mechanism central to understanding Brownian motion and phase transitions.

A Crookes radiometer, commonly known as a light mill, consists of a set of vanes mounted on a low-friction spindle within a glass bulb maintained at low pressure, as illustrated in the image below. Each vane is coated black on one side and white on the other. When exposed to light, the vanes rotate with the black sides moving away from the light source. The speed of rotation increases with the intensity of the light, and optimal performance is at a pressure of approximately 1 Pa.

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For over a century, scientists have debated the mechanism behind the rotation of Crookes radiometers. The device's inventor, William Crookes, initially suggested that the rotation was driven by the pressure of light, a theory consistent with James Clerk Maxwell's theoretical predictions. However, this explanation was later refuted. If light pressure were responsible, the white side of the vanes, which reflects more light, would experience twice the momentum and should

move away from the light source. In reality, the radiometer spins in the opposite direction, suggesting that another force is at work. Furthermore, if light pressure were the cause, one would expect faster rotation in a better vacuum. Yet, in a highly evacuated bulb, the vanes remain motionless. This also disproves the idea that the photoelectric effect is responsible for the rotation.

The air pressure theory suggests that air molecules striking the warmer side of a vane absorb heat and bounce off at higher speeds, generating more force. However, this explanation has some issues. While faster-moving molecules would exert more force, they would also collide with and prevent incoming air molecules from reaching the vane. Moreover, because the air near the black side of the vane is heated more than that near the white side, it expands more. As a result, the air near the white side becomes denser, which suggests the white side should experience higher pressure. This discrepancy led to the development of the thermal creep theory, one of the most widely cited explanations in the literature. According to this theory, gas molecules near the denser white side gradually "creep" over the edges of the vanes toward the black side, creating higher pressure on the black side and causing the vane to rotate. However, like all theories, thermal creep has its own limitations, which will be discussed later.

Given the unresolved nature of the understanding surrounding Crookes radiometers, we turned to **ChatGPT 4o** for clarity, hoping it might offer a more accurate explanation than Humen. The interactions were discussed in the article Potential Problems of AI Created Content. To further assess how different AI models handle such nuanced scientific questions, we also posed the same inquiries to **DeepSeek R1**. Below, we present a comparative analysis of their responses, highlighting key differences in reasoning, technical accuracy, and their ability to address unresolved scientific ambiguities.

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How Does a Crookes Radiometer Work?

ChatGPT:

A Crookes' radiometer is a device that consists of a set of vanes mounted on a spindle inside a vacuum-sealed glass bulb. The vanes are typically black on one side and white or reflective on the other. When exposed to light, the vanes spin, and this spinning motion can be quite striking, leading many to wonder how it works. Here's the basic mechanism behind it:

1. **Light Absorption and Heating:** The black side of the vanes absorbs more light and heats up more than the white or reflective side. When light (typically from the sun or a lamp) hits the radiometer, the black sides of the vanes absorb the energy and convert it into heat. The white side, on the other hand, reflects some of the light and doesn't heat up as much.
2. **Pressure Differences:** The difference in temperature between the two sides of the vanes creates a temperature gradient. This causes a difference in the air pressure on the two sides, with the warmer black side having a slightly lower pressure (because the air near it becomes less dense as it heats up), and the cooler white side having a higher pressure.
3. **Motion of the Vanes:** The higher pressure on the white side pushes the vane toward the black side, causing the vanes to spin. This motion is the result of the pressure difference caused by the unequal heating of the sides.

Why does it spin? While it seems like this might be a simple result of light pressure (like radiation pressure), it's actually the difference in air pressure inside the bulb that primarily drives the motion. The fact that the vanes are inside a vacuum

also means that the air density is much lower, so even small differences in temperature cause noticeable pressure differences that are enough to make the vanes rotate.

In short, it's a combination of thermal effects and the differences in air pressure that create the spinning effect! Cool, right?

DeepSeek:

A Crookes' radiometer operates due to thermal effects in a low-pressure gas environment, rather than direct light pressure. Here's a step-by-step explanation of its workings:

1. **Structure:** The device consists of a glass bulb containing a partial vacuum (low-pressure gas) and four vanes mounted on a spindle. Each vane is white on one side and black on the other.
2. **Light Absorption:** When light (especially infrared) strikes the vanes, the black sides absorb more energy and become hotter than the reflective white sides.
3. **Gas Interaction:** The low-pressure gas near the black sides is heated, increasing the kinetic energy of gas molecules. These molecules move faster and collide with the black surfaces more vigorously.
4. **Thermal Transpiration (Creep):** Gas molecules at the edges of the vanes experience a temperature gradient. Molecules from the cooler (white) side migrate toward the hotter (black) side along the vane surfaces, creating a tangential force that pushes the vanes.
5. **Momentum Transfer:** Faster-moving molecules from the heated black sides transfer more momentum when they collide with the vane, exerting a greater force compared to the cooler white sides. This differential force causes the vanes to rotate.
6. **Direction of Rotation:** The combined effects of thermal creep and differential momentum transfer result in the vanes spinning with the white sides leading, as the black sides are effectively pushed away by the escaping high-energy molecules.

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Key Factors:

- Partial vacuum allows gas molecules to have long mean free paths, enhancing thermal effects.
- Thermal gradients drive gas flow and differential momentum transfer.
- The rotation is not due to light pressure but thermal interactions between the vanes and residual gas.

This interplay of thermal transpiration and momentum transfer explains the characteristic rotation observed in a Crookes' radiometer.

Commentary:

ChatGPT’s analysis arrived at an incorrect conclusion, suggesting that the radiometer vanes rotate with the white sides being pushed away—a claim directly contradicted by empirical evidence. Surprisingly, it did not reference the widely cited thermal creep theory in the literature. Instead, the model focused on air pressure dynamics. Its reasoning aligns with its conclusion: the white side is cooler and denser, creating higher air pressure. While this explanation reflects the model's

capacity for creative problem-solving, it also highlights a lack of adherence to rigorous scientific methodology, which should be grounded in observation and established principles.

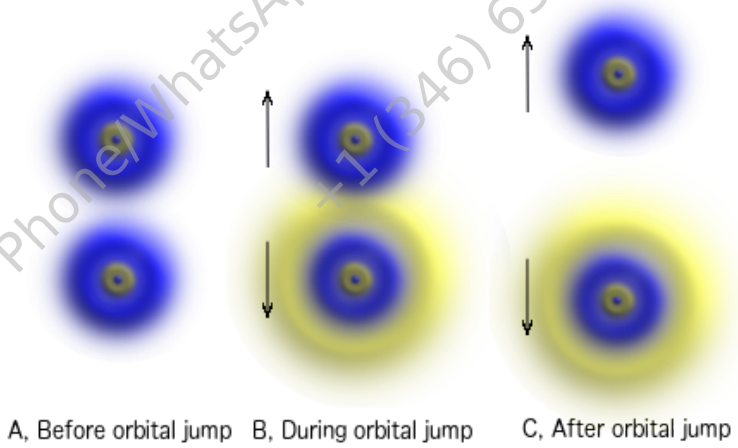
In contrast, DeepSeek correctly identified the direction of rotation. Its reasoning draws on both the air pressure and thermal creep mechanisms, which are the two most commonly cited explanations in the literature. However, its application of thermal creep is flawed. The tangential force from thermal creep actually acts in the opposite direction of rotation, which should hinder the operation of the radiometer, not support it.

Overall, while these large AI models possess a broad range of knowledge that helps them perform well on some standard tests, we were disappointed to find that their critical scientific reasoning abilities still fall short of those of humans.

Transimpact Theory

Although air pressure and thermal creep theories are commonly cited to explain the mechanism behind Crookes radiometers, there is no conclusive evidence supporting them, largely because it's difficult to conduct experiments for testing these theories within such a device. Additionally, these theories share a fundamental flaw: they fail to explain the rapid onset of rotation, particularly the initial acceleration. For the vanes to begin rotating, the driving force must be strong enough to overcome the friction between the vanes and the mounting spindle. If air movement due to pressure differences were the cause, the air inside the radiometer would need to heat up, creating the necessary pressure variations—a process that takes time. As a result, acceleration should start from zero and increase gradually as the air warms up. However, observations consistently show that acceleration begins at its maximum value and then decreases, contradicting the predictions of these air-based theories.

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These and other observations can be explained by a theory developed a few years ago, known as *transimpact*. According to this theory, the vanes are driven by a side effect of atomic electron transitions. When an electron in an atom absorbs energy, it excites to a higher orbital, causing the electron cloud to expand and reducing the distance between adjacent atoms within a few nanoseconds. This rapid reduction in interatomic space disrupts the balance of van der Waals forces, leading to an increase in repulsion between the particles. This process, referred to as *transimpact* (a term coined from "transition" and "impact"), is illustrated in the figure above.

When transimpacts occur between air molecules and the surface of a radiometer vane, the air molecules are ejected with significant momentum, similar to a popcorn kernel bursting, which propels the vane in the opposite direction. The black side of the vane, which absorbs energy more efficiently, experiences more electron excitations and transimpacts than the white side. This imbalance causes the vanes to rotate, with the black side being pushed away. Since atomic electron transitions begin immediately upon exposure to light, this theory predicts the largest initial acceleration, which then decreases as air resistance increases as the rotation speed picks up.

There was no direct proof of this theory until some experiments were developed recently. One notable experiment involved measuring the change in rotation speed under high-power flashlights. The rate of speed change, or acceleration, is directly proportional to the driving force, offering insights into the force behind the radiometer's motion. Experiments have shown a strong correlation between theoretical predictions and empirical observations, providing compelling support for the transimpact theory. This study has been available online for over five years and also offers insights into mechanisms behind Brownian motion and phase transitions. To determine whether ChatGPT and DeepSeek have been updated with this new knowledge, a follow-up question was posed.

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Do You Know the Transimpact Theory?

ChatGPT:

Yes! The transimpact theory is a concept that some physicists have proposed to explain the behavior of the Crookes' radiometer. It was introduced to account for the observed motion of the vanes, and the idea is a bit more complex and involves the idea of momentum transfer during molecular collisions in the context of thermal effects. Here's the essence of the theory:

Transimpact Theory Overview: The basic idea is that the transference of momentum from gas molecules to the vanes is not merely due to direct collisions but also due to energy transfer during the collisions, specifically the change in momentum when gas molecules strike the hot (black) surface versus the cooler (white) surface. The term "transimpact" refers to the idea that molecules that strike the vanes are not just reflecting off the surface; they lose energy to it (or gain energy, depending on the temperature gradient), and this results in a transfer of momentum that causes the vane to move.

Key Points of the Theory:

1. **Asymmetry in Molecule Behavior:** Gas molecules striking the hot black side of the vane transfer more momentum to the vane than those striking the cooler white side. This is because the gas molecules that come into contact with the hot surface undergo a change in momentum that is different from when they strike the cooler surface. The black surface, being warmer, causes more energetic molecular collisions, and the molecules rebound more strongly off this side.
2. **Momentum Transfer During Molecular Rebound:** When a gas molecule strikes the black side of the vane, it not only transfers momentum from the molecular kinetic energy but also experiences a change in its own motion after the collision, depending on how much energy it has gained or lost. This creates a net momentum transfer, causing a greater force on the black side than on the white side.

3. **Vacuum Effect:** The vacuum inside the radiometer enhances this effect because, in a vacuum, there are fewer gas molecules, but the ones that are there interact more directly with the vanes. The difference in temperature between the black and white surfaces accentuates the directional momentum transfer.

How This Explains the Rotation:

- **Black Side Leading:** In this framework, the black side leads because the energy and momentum transfer during molecular collisions is greater on the black (hotter) side than on the white (cooler) side. This results in a net force that pushes the vanes in such a way that they rotate with the black side leading.
- **The "Transimpact":** The "transimpact" concept suggests that, when molecules strike the vanes, they don't just bounce off. Instead, there's an interaction where energy is transferred between the gas molecules and the vane surface, causing the molecules to rebound with a net effect that creates torque on the vane. This asymmetry in energy transfer between the black and white sides is the driving force behind the rotation.

Why It Works Better Than Simple Thermal Effects: The classical explanation — based purely on temperature differences and air pressure differences — didn't fully account for why the vanes spin with the black side leading. The transimpact theory fills this gap by suggesting that it's the difference in momentum transfer due to thermal interactions between gas molecules and the vane surfaces that's primarily responsible for the observed motion.

Conclusion: The transimpact theory essentially says that the behavior of the radiometer isn't simply due to differences in thermal radiation or pressure but involves more complex interactions between the heated gas molecules and the surfaces of the vanes. This theory helps explain the reverse spin, with the black side of the vane leading, as a result of these enhanced molecular collisions and the associated momentum transfer.

It's a fascinating theory and one that has intrigued scientists since the radiometer's invention, providing a more detailed understanding of how thermal gradients and gas behavior can combine to create macroscopic motion.

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DeepSeek:

The term "transimpact theory" does not correspond to a widely recognized or established concept in mainstream physics or scientific literature. It's possible that the term is being used in a niche context, as a misinterpretation, or as a conflation of ideas related to momentum transfer and thermal effects in systems like the Crookes radiometer.

If you encountered this term in a specific context (e.g., an alternative explanation for radiometer behavior), here's how it might relate to known physics:

Possible Connections to Known Physics:

1. **Thermal Transpiration (Thermal Creep):** In the Crookes radiometer, gas molecules near the edges of the vanes experience a temperature gradient. This causes gas to "creep" from the cooler (white) side to the hotter (black) side, creating a tangential force that contributes to rotation. This process is sometimes called thermal transpiration.
2. **Momentum Transfer (Radiometric Effect):** The black sides of the vanes absorb more heat, heating the adjacent gas. Faster-moving gas molecules striking the black sides transfer more momentum than cooler molecules on the white sides, creating a net force. This is often referred to as the radiometric effect.

3. If **"transimpact theory"** combines these ideas (transfer of momentum + thermal gradients), it might be an informal way to describe the interplay of thermal creep and molecular collisions that drive the radiometer's motion.

Why "Transimpact" Isn't Standard Terminology:

- The Crookes radiometer's operation is explained by classical thermodynamics and kinetic theory, not a standalone "transimpact" theory.
- The term may stem from older or less rigorous attempts to explain the radiometer before modern understanding of gas kinetics and thermal gradients.

If you have more context about where you encountered "transimpact theory," I'd be happy to help clarify further! For now, the key takeaway is that the radiometer's motion arises from **thermal effects in low-pressure gas**, not direct light pressure or a unique theoretical framework.

Commentary:

While ChatGPT may seem to engage with transimpact theory, its responses are not actually grounded in the theory itself or any legitimate interpretations of it. Instead, its responses are generated solely from conventional theories of air pressure and aerodynamics. For those unfamiliar with transimpact theory, this conflation of concepts poses a risk of significant misunderstandings, as the output may appear to offer relevant analysis when, in reality, it is entirely unrelated. This highlights a potential risk of generative AI: its ability to produce seemingly coherent but misleading information.

In contrast, DeepSeek transparently acknowledges its unfamiliarity with the term and carefully attempts to reason through established frameworks to hypothesize potential origins or meanings. It further offers its willingness to refine or clarify the concept if additional context is provided. When selecting a tutoring model for minors—where accuracy, transparency, and intellectual humility are critical—DeepSeek's approach of openly addressing knowledge gaps and methodically bridging them may align more closely with educational priorities than a system prone to generating speculative responses.

Their responses suggest that both models failed to incorporate more recent, though less-cited, knowledge. Since this new information was available online before the models' training, it should have been included in their data. This highlights a limitation in the current training process, which seems to prioritize the volume of widely referenced data over the relevance of newer, less-cited information—an approach that contrasts with how humans prioritize learning.

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- Unified Theory of Low and High-Temperature Superconductivity (PDF)
- Superfluids Are Not Fluids (PDF)
- Electron Tunnel (PDF)
- The Cause of Brownian Motion (PDF)
- The Process Driving Crookes Radiometers (PDF)
- Can Temperature Represent Average Kinetic Energy? (PDF)

- Why Phase Transition Temperature Remains Constant (PDF)
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