Shadowing Fails for Casimir + The van der Waals Magnet Analogy

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2023-09-03.23:56 EDT Sun
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A Comment on the SciShow (YouTube) post:
The Weight of "Nothing" Could Mean Everything (to Physics) (Aug 29, 2023)
https://youtu.be/szI-HpOScFQ

Hanasei Levinus, an update: This has been interesting and annoying. I tried on my own to figure out how wave shadowing — and I should note that I'm not the first to use that analogy — contributes to the Casimir force. I got… well, nothing. It doesn't work.

I can create very short-range van der Waals fields that, if you squint hard, *kind of* look like vacuum fluctuations. However, they are nothing more than electrons and protons jostling around to create short-range electromagnetic textures that invite nearly charges to settle into lower-energy configurations. Unfortunately, these atomic-scale textures of electromagnetic fluctuations — the fields of the van der Waals attraction — have as much to do with vacuum fluctuations as getting vitamin pills to pack more tightly in a bottle if you jostle them gently.

Nonetheless, I thought that maybe these van der Waals fields might, at least, serve as the choppy "open water" waves I mentioned. Alas, guess what: It doesn't work. What is happening is that the van der Waals fields between the plates are *collapsing* with enough release of energy to pull the plates gently together. What happens on the other sides of the plates — the supposed "pressure" of the vacuum — doesn't seem relevant. That makes sense since if they didn't, you wouldn't have energy conservation, would you? I like energy conservation; it works!

At this point, I am baffled as to how all the "standard" harmonic particle-in-a-box state analysis of photon modes between the plates has *anything* to do with Casimir, even as a calculation aid. Maybe some of the van der Waals charge jostling occurs at frequencies that get quantized? Wow. I don't see it. You don't even *have* that neat flatness at these atomic scales, not with bumpy, lumpy, fuzzy atoms all around.

Casimir is just a collapsing van der Waals field. Nor do I seem to be the only one who thinks that! After working myself into exactly that corner, I looked closer at the 2005 Jafee paper and found this:

"The Casimir force is simply the (relativistic, retarded) van der Waals force between the metal plates."

For those of you wondering, "retarded" here means nothing more than "lagging a bit in time due to finite light speed." Physicists got the term from crankshaft timing, no kidding.

Since Casimir is nothing more than an overly complicated and even deceptive way of talking about the very van der Waals forces, I'll leave with this analogy:

The van der Waals Magnet Analogy

Take a dozen refrigerator disk magnets. Flip half of them over so they stick to each other, and arrange them into two parallel snake-like rows. A question: Will the two rows attract or repel?

Answer: It depends. If you shift one row up or down a bit relative to the other, you'll notice that the rows alternate between attraction (when N magnets in one chain are closer to S magnets in the other chain) and repulsion (when N is near N and S is near S).

However, the attraction eventually dominates if you jostle the chains a bit. Why? The attractive configurations release energy while the repulsive configurations absorb, so random jostling — entropy — favors falling into the lower-energy state.

Note also that this attraction between the chains only applies at close distances. In the distance, each has zero net magnetic field. It's only up close that they begin to see each other's structure and jiggle around a bit into the state, making them attract slightly.

Translate all of this into protons and electrons rather than magnets, and that's the van der Waals force.

Notice that a magnetic field also emanates a short distance from each of the chains. There has to be, house the van der Waals force could never exist. It's a messy field that doesn't extend very far but has structure and the ability to attract. That means it also has energy, which turns out to be important.

In the case of two nearby metal plates, both plates are surrounded on both sides by a feeble field of complicated and slightly mobile electric "charge texture." Both plates must expend a bit of energy to create these fields. When the plates get close, the electrons and positrons "see" each other's electromagnetic textures to cause a bit of mutual jostling into more attractive positions. The van der Waals fields collapse, and the tiny release of energy pulls the plates closer.

Conclusion: Large-plate van der Waals forces — Casimir forces — are intriguing. Alas, though, none of this has anything to do with spacetime. It's just atomic-scale "let's get cozy" jostling of positive and negative charges.