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On The Ontological Commitment of Potentials and Fields

In July 2017, the MMS spacecraft approached the Earth's dawn side in its regular orbit. As it came close to the reconnection region (a region where the magnetic field changes directions), sensors aboard Juno measured the electric field of the Earth with the purpose of mapping it (to eventually compare models of the reconnection process). Likewise, by measuring the impact of charge particles on a detector, the cluster spacecraft can measure the energy of ions and electrons in the region. In the paper modeling this flyby, we read statements such as: "the measured reconnection electric field (E_y in this article) is sufficient to energize ions to 10 times the initial thermal energy." (Sega & Ergun., 2024). This short essay will answer the question of how are we to understand this and other statements about electric fields (and potentials). The goal is to analyze the **E**-field in terms of the V potential V (or viceversa) on the grounds of one or the other being the more fundamental quantity. Hopefully, after doing this, we can get a better insight into how the above statement is to be understood.

One may ask if these measurements of the electric field around Earth are to be understood, ultimately, as describing the potential difference close to Jupiter, which is the real physical object. We can also consider that nothing more is to be understood by these electric field measurements other than just describing the electric field around Jupiter, which is a real physical object. The last question we'll be addressing is if it makes a difference? Is speaking in terms of "V" or "**E**" similar to the case of saying "car" or "automobile"? Can we really reduce one term to the other, and what do we gain by doing so?

Metaphysics

I'll clarify the way in which I will be using the terms "property" and "object". I'll start with the linguistic and somewhat vague subject-predicate distinction with the hope of capturing some common-sense ideas (also, for the purpose of this essay I don't need to be more precise than this). Note that we normally ascribe properties to objects through predication, while objects are referred to in the subject of sentences. If I say that "George is tall", then I'm ascribing to George the property of being tall. We may also speak of properties as subjects in our sentences, as in "red is a color". Is red then, a property or an object? Our subject-predicate analogy breaks down here, and this dilemma usually leads to *universals and particulars*. Red, as seen in *particular* objects, is thought of as a property, but if we were to talk about red as an object in itself (let's call this object redness), we would be talking about a *universal*. Roughly speaking, universals are things that many particulars have in common; luckily, we don't have to deal with this complicated universal/particular distinction since magnetic fields are usually mentioned in the subject of a sentence (as in the opening remark). [1]

What do I mean by "objects" then? I mean that we can talk about them in the same way that we talk about chairs and tables. This is not to say that chairs and tables are anything like electromagnetic fields, it is just to say that they appear in our sentences in a similar way that chairs and tables appear. One may also speak of magnetic fields and vector potentials as properties of a point **p**, or a region R, in spacetime as well, but in this essay, I will speak about fields and potentials as extended

objects in space. This choice is debatable, but the essay will be centered on the question of which one (**E** or V) is more "real", and hopefully this is independent of this choice.

This brings us to my next point about reality, yet another debated term in metaphysics. I will start by saying that to be real is to exist, and what we mean by "to exist" is associated roughly with the existential quantifier ∃. In this, I'm following Quine on "On What There Is" (Quine W. V., 1961). In his famous essay, he roughly says that to exist is to be quantified over in a true sentence; we need some things to exist in order for some of the propositions we utter (in science) to come out as true, and this is explicit in the analysis of propositions through quantificational logic**. This weak version of existence allows for the existence of both E and V.**

In summary, properties are instantiated by objects; we refer to objects as the subjects in our sentences which in turn transform, under analysis, in an existential quantifier. To exist is to be picked out by the existential quantifier in a true proposition. And not to forget, these philosophical concepts are being brought forward because we are "regimenting" the language used to talk about magnetic fields and vector potentials.

Conclusion

After applying the notions of ontological commitment to the case in hand, we are left with the existence of many fields. Infinitely many V, and **E**. This comes about by analyzing sentences involving these fields with the existential quantifier, and noting that they come out true, as far as we verify these claims by looking at physical systems. Astronomers can rest assured that, under Quine's regimentation, they are being very precise in their description of the physical environment around Earth in terms of **E**, and not as a potential difference.

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