Maxwell, Kelvin, the inverse square law, and epistemic injustice

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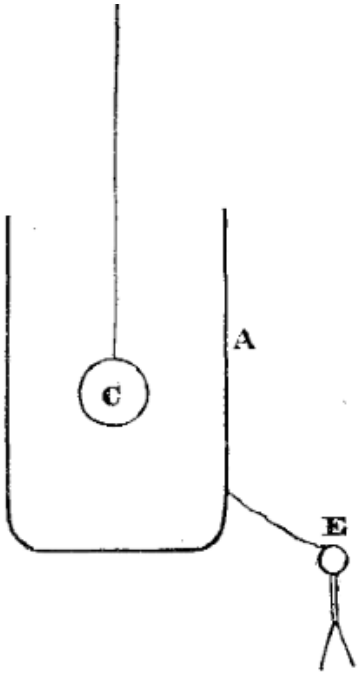
21 June 2018

Maxwell & MacAlister's 1877 version of Cavendish's 1773 $1/r^2$ apparatus

"Epistemic Injustice in Mathematics", Colin Rittberg, Fenner Tanswell, Jean Van Bendegem

"Maxwell, Kelvin, and the inverse square law", Isobel Falconer



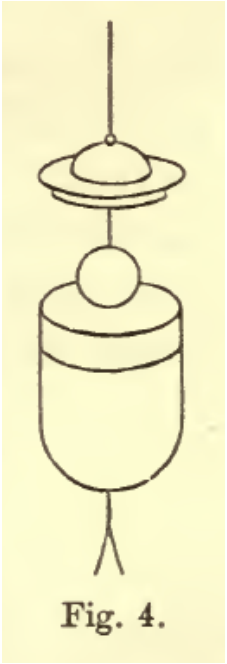


Fig. 4.

This talk

- Examines Kelvin & Maxwell's treatment of the inverse square law of electrostatics as a possible case of epistemic injustice.

  Kelvin and Maxwell invented a British tradition (Cavendish and Faraday) to promote a mathematical-deductive approach to physics in place of an inductive one. (Falconer, 2017)

- Asks
  - Can this historical case study inform the discussion of epistemic injustice?
  - Is the lens provided by epistemic injustice useful in analysing such historical cases?

What is Epistemic Injustice?

A branch of virtue epistemology

An epistemic vice

Epistemic injustice is a kind of injustice that is done to people in their capacity as epistemic agents and as knowing subjects (Rittberg et al, p2)

A wrong *"done to someone specifically in their capacity as a knower"* (Fricker 2007, p1)

It includes unjust impediments to one's capacity as an *inquirer* (Anderson 2015)

Types of Epistemic Injustice

Hookway (2010):

- Informational Perspective: evaluates epistemic agents in terms of their ability to give and receive information

  Fricker (2007)

  - Testimonial Injustice: *a speaker receives an unfair deficit of credibility from a hearer owing to prejudice on the hearer's part*

    Battaly (2017)

    - Effects vice
    - Personalist vice
    - Responsibilist vice

  - Hermeneutical Injustice: *someone has a significant area of their social experience obscured from understanding owing to prejucidial flaws in shared resources for social interpretation*

- Participant Perspective: whether an agent is able to be a proper participant in some epistemic endeavour

Epistemic Injustice in the history of physics and mathematics

- Grasswick (2017) takes a participant perspective:
  - *When scientific research programs are directed toward the needs of the privileged, structural gaps in conceptual and empirical resources evolve resulting in hermeneutical injustices that disadvantage subordinated groups in their ability to come to understand their experiences and convey that understanding to others* (p315)
- Ethnographic studies such as Latour & Woolgar (1986) of science, and Lane (2017) of mathematics provide rich material for (contemporary) case studies
- Rittberg, Tanswell and Van Bendegem – in preparation
- Kidd - yesterday

Exploring injustice in the case study

(Some of the) Questions

- How to handle changing epistemic standards?
  - *"sparks and shocks which are seen and felt,"* to *"currents and resistances to be measured and calculated* (Maxwell 1873)
- Is one group clearly subordinate?
  - Were K and M members of a privileged dominant group?
  - Did the other group(s) display an epistemic vice in not learning mathematics? In not going to Cambridge to learn mathematics?
- Can epistemic vices be justified by epistemic outcomes?
  - Is my sense of shock over K and M's epistemic irresponsibility mitigated by the epistemic value of the outcomes?

Sources

- Works by Kelvin and Maxwell in the 1870s, aimed at an educated, but not (yet) mathematically trained audience

Chronology in textbooks 1840s-70s

- Inverse square law of electrostatics: $F \propto q_1 q_2 / r^2$
- Cavendish 1771 inverse square law predicts no charge inside a closed charged conductor
  - 1773 confirmatory experiment (unknown until 1878)
- Coulomb 1785 torsion balance experiments
  - 3 data points
- 1800s–10s Laplace and Poisson potential theories: inverse square law predicts no charge inside a closed charged conductor
- 1830s-50s Snow Harris et al numerous experiments which gave other laws
- Faraday 1838-43 experiments on electrostatic *induction*

The inductive tradition: Webb

Although the attractive force may…vary within certain limits…as some particular power of the distance, if increased beyond these limits, the ratio will begin to vary, and ultimately the attractive force will vary as some other power of the distance

(Frederick Charles Webb, in *The Electrician,* 1862)

The inductive tradition: Snow Harris

If we examine the physical data upon which … the laws of these forces rest, we do not find the experimental investigations to be extensive, nor are they always satisfactory …

It is easy to see that the limit of the law of electrical or magnetic force is a simple inverse ratio of the distance…It is only, then, between certain limits, and under certain free states or conditions of magnetic or electrical change, that we obtain the law arrived at by Coulombe [sic].

(Sir William Snow Harris, *Treatise on Frictional Electricity*, 1868)

The deductive tradition: Kelvin 1845

Law must be true because mathematics determined its form

- [*Coulomb] arrived by direct measurement at the law, which we know by a mathematical demonstration, founded upon independent experiments, to be the rigorous law of nature for electrical action*
- referenced Robert Murphy (1833), and John Pratt (1836) for the mathematical demonstration, but did not specify the "independent experiments"
- *Of late years some distinguished experimentalists have begun to doubt the truth of the laws established by Coulomb…*

(William Thomson, 'On the mathematical theory of electricity in equilibrium, 1845)

The deductive tradition: Kelvin 1854

1854 revision added a note:

- *Cavendish demonstrates mathematically that if the law of force be any other than the inverse square of the distance, electricity could not rest in equilibrium on the surface of a conductor. But experiment has shown that electricity does rest at the surface of a conductor. Hence the law of force must be the inverse square of the distance*
- specified the relevant class of experiments for the first time, but remained silent about who had performed them

421. **Electricity resides on the Surface.**—Electricity (subject to the

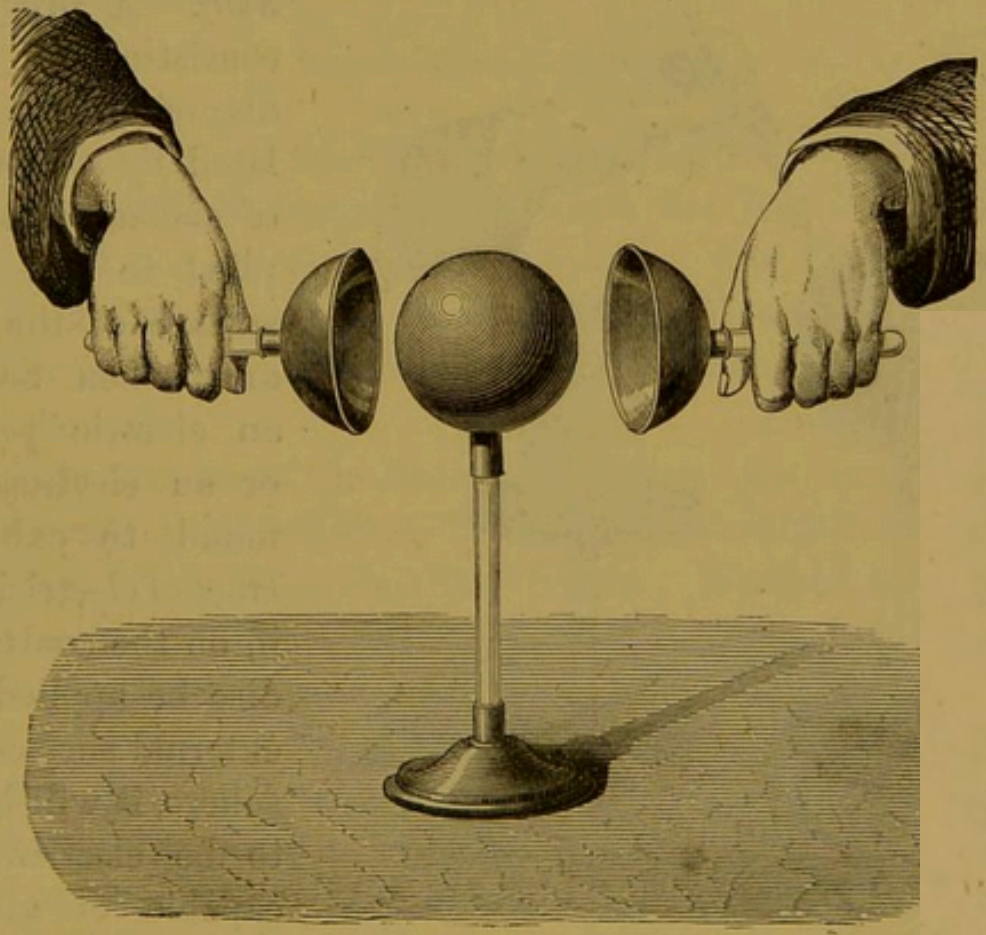


Fig. 342.—Biot's Experiment.

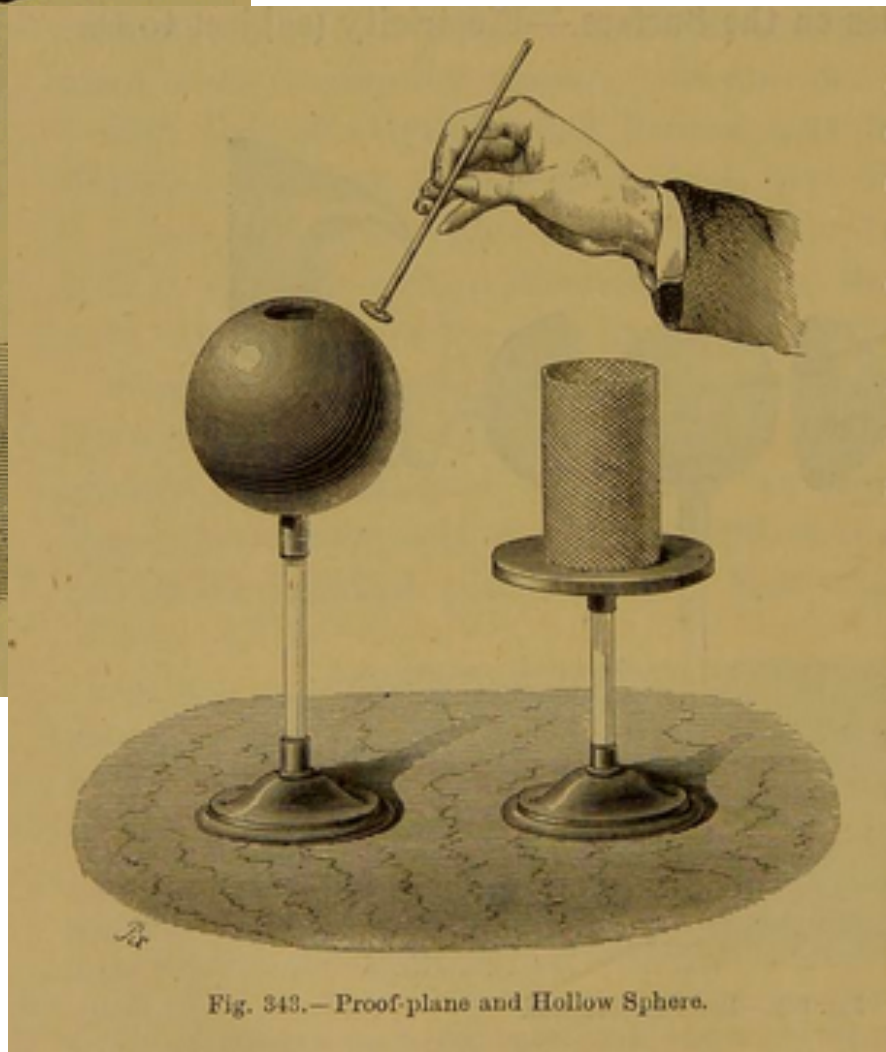


Fig. 343.—Proof-plane and Hollow Sphere.

J.D. Everett, 1872,
Elementary Treatise on Natural Philosophy, p523-4

Maxwell 1873 on inverse square law

The results … from [Coulomb's] experiments must be regarded as affected by an error depending on the probable error of each experiment…. As an argument that the attraction is really, and not merely as a rough approximation, inversely as the square of the distance, [Faraday's null experiment] is far more conclusive than any measurements of electrical forces can be…

(Maxwell, 1873, *Treatise on Electricity and Magnetism,* 1st edn)

Kelvin 1876 on inverse square law

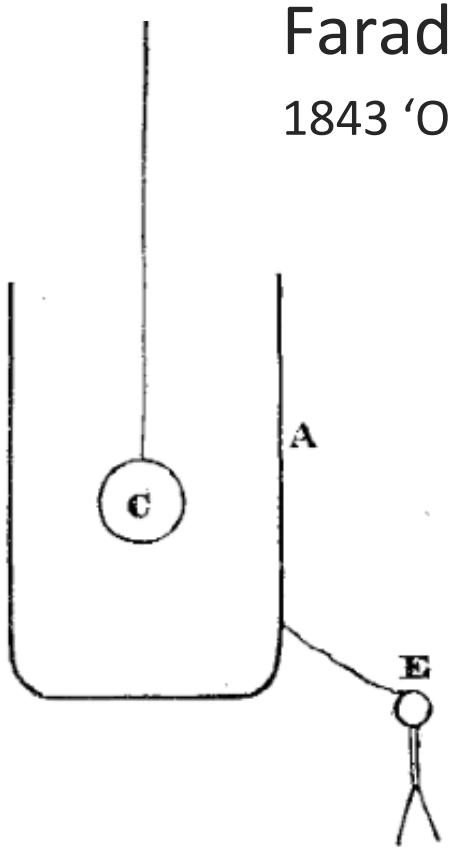
It was left for Faraday to make … the … experiment which crowned Cavendish's theory. Faraday found by the most thoroughly searching investigation that the electrical force in the circumstances supposed was zero.... Therefore the law of force varies with the inverse square of the distance. This result was obtained with far less searching accuracy by Coulomb and Robinson, because their method did not admit of the same searching accuracy. On this law is founded the whole system of electrostatic measurement in absolute measure.

(William Thomson, 1876, 'Electrical Measurement', Lecture at South Kensington)

Faraday's experiment

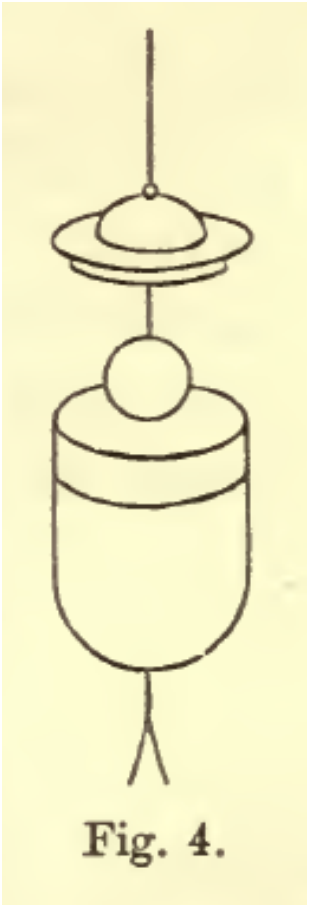
Faraday's drawing of his apparatus

1843 'On static electrical inductive action'



Maxwell's drawing of Faraday's apparatus

1871 *Treatise on Electricity and Magnetism*



Was K & M's treatment of Faraday's work epistemically irresponsible in a "good cause"?

Does this case count as epistemic injustice? To whom?

Summary

- K & M arguing for the superiority of the null method over Coulomb's inductive method. Crucially, mathematical competence, and belief in the physical necessity of the mathematical prediction, were necessary to justify the null method
- Their argument was faulty (in at least 3 ways)
- Represents a case where epistemic standards were in flux

Some discussion question

- 3 “groups” in this case?
- Were K and M the “dominant group”? Does our perception of them as epistemically irresponsible change if we view them as a subordinate group?
- Were K and M taking aim at the non mathematically trained, or at the non *Cambridge* mathematically trained? Does the answer affect our perception of their epistemic vices?
- If this is a case of epistemic injustice, who was wronged, and in what ways?
- Hence, what “type” of epistemic injustice is it?

More discussion questions

- Is denying dead actors a voice epistemically unjust?
- "Retelling" the history of their field/results is part of scientific and mathematical (and historical) practice. Are they being epistemically irresponsible or unjust?
- Do historical processes change/morph one type of epistemic injustice into another (e.g. hermeutical -> testimonial)
- How well does the framework of epistemic injustice stand up to situated and ambiguous historical cases?
- Enquiry into epistemic injustice in historical cases may elucidate past epistemic practices

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