Theory of relativity and pathological science

In March of 1918 Sir Arthur Stanley Eddington and his assistant E. Cottingham, went to the island of Principe off the West Coast of Africa—with a second party stationed in Sobral, Brazil—to prepare for an experiment that would observe a total eclipse of the sun, and provide conclusive proof of Einstein's theory of relativity. [1] On 29 May 1919 they photographed a solar eclipse providing the basis for Eddington's claims of proving Einstein's theory. The results of the experiment caused an international sensation, with Eddington being credited as the man who finally verified Einstein's revolutionary theory. Recently, the experiment and its results have been the subject of debate. Eddington's methods and the nature of the experiment have cast doubt over its validity. Considered within Irving Langmuir's notion of ' pathological science', this paper argues that Eddington's canonical experiment displays many symptoms associated with pathological science, showing the danger of performing scientific experiments with predictions already in hand, and that have been derived from theory alone.

Regarding the theory of relativity, it was agreed that according to both Newton and Einstein's theories, a strong gravitational field should have an effect on light rays. If Einstein's theory were correct, light coming from the stars should be observably more bent during a solar eclipse as they pass through the sun's gravitational field than in Newton's theory. Einstein believed that a star's light would be shifted twice as much. The expected displacements were 0. 87 second of an arc in Newton's theory versus 1. 74 seconds of arc for Einstein's. [2] Since the sun's gravitational effect is much greater on light than that of the earth, a solar eclipse was the only way of experimentally verifying Einstein's predictions. On the day of the experiment several problems existed. Skies were cloudy when the pictures were taken, and many problems were associated with the equipment. However, Eddington was able to obtain some useable data and presented the results at a special joint meeting of the Royal Astronomical Society and the Royal Society of London on 6 November 1919. [3] The results from Sobral provided measurements from seven stars that gave a deflection of 1. 98 ± 0. 16 arc seconds, with results from Principe recorded at 1. 61 ± 0. 40 arc seconds. [4] As Peter Coles states, “ Both were within the two standard errors of the Einstein value of 1. 74 and more than two standard errors away from either zero or the Newtonian value of 0. 87. Einstein had hit the jackpot.” [5]

On December 18, 1953, Dr. Irving Langmuir—Nobel laureate in chemistry in 1932—gave a lecture at the Knolls Research Laboratory where he addressed, “ the science of things that aren’t so”, giving examples of a problem he called ‘ pathological science’. [6] Langmuir identified six ‘ symptoms’ of pathological science:

1. The maximum effect that is observed is produced by a causative agent of barely detectable intensity, and the magnitude of the effect is substantially independent of the intensity of the cause.
2. The effect is of a magnitude that remains close to the limit of detectability; or, many measures are necessary because of the very low statistical significance of the results.
3. Claims of great accuracy.
4. Fantastic theories contrary to experience.

5. Criticisms are met by ad hoc excuses thought up on the spur of the moment.
6. Ratio of supporters to critics rises up to somewhere near 50% and then falls gradually to oblivion. [7]

While a case could be made that each one of these symptoms can be found in Eddington's experiments, this paper will focus on two of them in particular —number two and number five.

Experiments that fall into symptom number two have the common characteristic that they are very near the threshold of visibility of the eyes. The solar eclipse and the evidence it produced falls directly into this category. Collins and Pinch state, " It is as though a star whose light grazed the edge of the sun would appear to be displaced by a distance equivalent to the width of a penny viewed from a mile away." [8] Problems arising from this symptom are that data is easily rejected. According to Langmuir, " If things were doubtful at all", scientists " discard them or not discard them depending on whether or not they fit the theory." [9] This is exactly what Eddington did with his results from Principe. He used only two photographic plates out of a total of 26 produced. From the plates, 18 were of very poor quality. These were completely ignored in his presentation and irrelevant to the experiment. His justification for this is related to the next symptom of pathological science. The fifth symptom maintains that any criticisms are met by ad hoc excuses thought up at the spur of the moment. When confronted about the unused plates, Eddington justified ignoring the results by claiming they suffered from systematic error. However he was unable to produce any convincing evidence to show that this was the case. When he chose which observations to keep and which to throw away, Eddington had Einstein’s prediction very much in mind. [10]

The general lessons to be learned from Eddington’s work relate to the difficulties encountered when performing an experiment to verify a prediction based off theory. In Eddington’s interpretation of the observations, he “ seemed to confirm not only Einstein’s prediction about the actual displacement, but also *his method of deriving the prediction from his theory* —something that no experiment can do.” [11] Eddington claimed to confirm Einstein because he had used Einstein’s derivations in interpreting what his observations really were, with the further paradox that Einstein’s derivations only became accepted because Eddington’s observations appeared to confirm them—“ Observation and prediction were linked in a circle of mutual confirmation rather than being independent of each other as we would expect according to the conventional idea of an experimental test.” [12]

Henry H. Bauer argues that ‘ pathological science’ is not scientific misconduct, and not done intentionally. [13] Eddington was not purposely misguiding the scientific community. He was victim to common problems confronted by all scientists, especially physicists. As Trevor and Pinch note,

We have no reason to think that relativity is anything but the truth…but it is a truth which came into being as a result of decisions about how we should live our scientific lives, and how we should license our scientific observations; it was a truth brought about by agreement to agree about new things. It was not a truth forced on us by the inexorable logic of a set of crucial experiments. [14]

Bibliography

1. Bauer, Henry H. ‘ Pathological Science is not Scientific Misconduct, (nor is it pathological)’, *Hyle—International Journal for the History of Chemistry,* 8(1), 2002, pp. 5-22.
2. Coles, Peter. *Einstein and the Total Eclipse* . London: Icon Books, 1999.
3. Collins, Harry and Pinch, Trevor. *The Golem: what everyone should know about science* . Cambridge: Cambridge University Press, 1993.
4. Langmuir, Iriving. ‘ Pathological Science’. Trans R. N. Hall. *Colloquium at the Knolls Research Laboratory* , December 18, 1953.

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Footnotes

[1] Harry Collins and Trevor Pinch, *The Golem: what everyone should know about science* (Cambridge: Cambridge University Press, 1993), p. 44.

[2] Peter Coles, *Einstein and the Total Eclipse* (London: Icon Books, 1999), p. 52.

[3] Coles, p. 52.

[4] Coles, p. 52.

[5] Ibid.

[6] Irving Langmuir, “ Pathological Science”, trans. R. N. Hall, *Colloquium at the Knolls Research Laboratory* , December 18, 1953, section 3.

[7] Ibid.

[8] Collins and Pinch, *The Golem* , p. 44.

[9] Langmuir, ‘ Pathological Science’, section 3.

[10] Collins and Pinch, p. 45.

[11] Ibid.

[12] Ibid.

[13] Henry H. Bauer, ‘ Pathological Science is not Scientific Misconduct, (nor is it pathological)’, *Hyle—International Journal for the History of Chemistry,* 8(1), 2002, p. 5.

[14] Collins and Pinch, p. 54.