

## Realism and the Bullet Cluster

### Extended Abstract for &HPS2 Conference

In 2006, the astrophysicists Douglas Clowe and his colleagues made the startling claim to have discovered by inspection of the cosmological phenomenon, the ‘Bullet Cluster’, direct empirical proof of the existence of dark matter, the mysterious hypothetical substance thought to make up approximately 25% of the universe (as compared to 5% for regular luminous matter, the matter that we commonly see around us, and dark energy, yet another mysterious substance thought to be a form of ‘repulsive gravity’ making up the remaining 70%). As it happens, Clowe *et al* are motivated to advance this claim of direct evidential support for dark matter in response to attacks on dark matter’s existence posed by the Israeli astrophysicist Moti Milgrom (who defends alternatively the MOND, or Modified Newtonian Dynamics approach) as well as by the Canadian physicist John Moffat (who advocates the MOG, or Modified Gravity strategy). Each of the latter physicists contends that their alternate gravity theories can explain the extant phenomena (such as the data concerning galactic rotation curves) as successfully as the hypothesis of dark matter.

Clowe *et al*’s view is that to adequately respond to these alternatives they need to adduce what they call ‘direct’ evidence for the existence of dark matter. In this context, my first task in this paper is to analyze what Clowe *et al* mean in saying that a theoretical construct, dark matter, is ‘directly observed’. Unfortunately, they do not make analytically clear what they mean when they say that they have direct empirical proof for the existence of a theoretical entity such as dark matter, but I think the intuitive idea they are working with is fairly clear: seeing something directly is better evidence for its existence than inferring its existence on the basis of (thus, indirect) evidence. For example, seeing a person directly, say if this person is standing in front

of you in broad daylight, is better evidence for a person's existence than inferring her existence on the basis of a sun-cast shadow. Philosophers have long been cynical about the possibility of there being epistemically significant direct evidence of this sort, despite its seeming intuitiveness. In this paper I address these concerns by proposing the following definition of 'direct evidence': given two evidential claims (claims expressing evidence for a proposition), the first evidential claim is 'direct' relative to the second evidential claim if the set of background information that underpins the first claim is a subset of the set of background information that underpins the second claim. As such, the first claim is less vulnerable to refutation than the latter since it is less dependent on background assumptions. For example, seeing a person in broad daylight depends on a certain set of assumptions if it is to indicate the existence of this person (particularly assumptions regarding the normalcy of vision), the same assumptions needed if one's seeing a sun-cast shadow is to indicate the existence of this shadow. But going further and inferring the existence of a person on the basis of this shadow involves additional assumptions (assumptions mainly about the relevant laws of optics) that put this inference at greater degree epistemic risk than the original observational claim. In this way direct evidence is stronger evidence for a hypothesis than indirect (i.e., less direct) evidence. This is the sense in which Clowe *et al* say that they have direct evidence for the existence of dark matter: they mean 'direct' as compared to the other main line of support for dark matter which involves inferring the existence of dark matter on the basis of observations of (particularly) galactic rotation curves. With such direct evidence, Clowe *et al* believe they can out-manuever the critiques of Milgrom and Moffat and put the existence of dark matter on secure epistemic footing.

After this analysis of Clowe *et al*'s claim to have direct evidence for dark matter, I turn to the question of what the implications are for scientific realism if one sanctions their approach.

As it well known, one of the main pillars of support for scientific realism is the miracle argument that grounds a realistic interpretation of scientific beliefs on the basis of the inference that such an interpretation best explains the empirical success of these beliefs. To a certain extent such a style of argumentation has had an influence in promoting a belief in dark matter. Ultimately however such an inference has proved unsatisfying to a number of astrophysical researchers, such as Clowe *et al*, since there is non-negligible room to question this inference as Milgrom and Moffatt do. Instead, what astrophysicists find more convincing, much as the rest of us find more convincing, is to directly see a theoretical entity in the sense specified above. Using then the account of direct evidence outlined above, and in the backdrop of the work by Clowe *et al*, I respond to three sorts of criticisms that have been advanced against a realist interpretation of theories, criticisms designed to expose weaknesses in the miracle argument. Specifically I examine three arguments against realism based on the three following problems:

- 1) The problem of theoretical underdetermination, that for any theory there is another theory, logically incompatible with the first, with which it is empirically equivalent.
- 2) The problem of the ‘pessimistic meta-induction’, according to which given the evident falsity of past scientific theories our current theories are likely false too.
- 3) The problem of ‘unconceived alternatives’, as formulated in Stanford (2006), which emphasizes that, for any particular body of empirical evidence which supports at some a particular scientific theory, there is yet another scientific theory incompatible with the first which this scientist has not conceived of which is equally supported by this evidence.

My strategy is to examine each of these problems explaining why they pose a threat to the miracle argument and thus to scientific realism, and to then show how each can be effectively responded to on behalf of scientific realism using the strategy of direct evidence outlined here.

## References

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