Causal Explanation and Ontological Commitment

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The business of *Selective Realism*, is to distinguish the denoting terms from the non-denoting terms in our best scientific theories. This is no easy matter, and despite agreement amongst many philosophers of science that at least some of our scientific vocabulary denotes and some does not, there is very little agreement about how the demarcation in question is to be affected.[1] One strategy that enjoys fairly widespread support, however, is the appeal to a causal test.[2] According to this view, the only terms that are taken to denote are those concerning causally active entities. Such an approach rules against the existence of abstracta but maintains realism about theoretical entities such as electrons and the like. In this paper I will consider one important defence of such a test due to David Armstrong. I argue that this defence fails because of its reliance on the assumption that only causally active entities can have explanatory power

1. Armstrong's Argument

The most thorough defence of a causal test such as that described above, is presented by David Armstrong (1978; 1980; 1989). Armstrong starts from a broadly naturalistic point of view, taking as self evident that there is a physical universe. The question is whether we need to posit abstract entities such as classes as well as the physical entities? Armstrong concludes that we do not. His argument in essence runs like this: abstract entities could not act on physical entities; Occam's razor then counsels us not to postulate them (1980). His appeal to Occam's razor is very interesting. He seems to think that because abstract entities, such as classes, cannot act on physical entities, they lack explanatory power. Indeed, Armstrong suggests as much in a couple of places. In (Armstrong 1980) he asks the rhetorical question:

> In what way, then, can [abstract classes] help to explain the properties and behaviour of physical things? (Armstrong 1980, 155)

And elsewhere he elaborates:

> To postulate entities which lie beyond our world of space and time is, in general, to make a speculative, uncertain, postulation. The postulation may perhaps be defended if it can be presented as explaining some or all of the spatio-temporal phenomena. But if the entities postulated lie beyond our world, and in addition have no causal or nomic connections with it, then the postulation has no

[1] There is no shortage of proposals though. For example, van Fraassen (1980) privileges the vocabulary that concerns observables; Quine (1980) privileges the vocabulary that is "indispensable" to our best scientific theories. These give very different results. Quine finds that a large part of mathematical vocabulary—'real number', 'function' and the like—denotes as well as theoretical vocabulary such as 'electron', 'neutron star' and the like. Van Fraassen, on the other hand, denies that any of these denote.
[2] See (Armstrong 1997), (Campbell 1994) and (Ellis 1990), for instance.

explanatory value. Hence (a further step of course) we ought to deny the existence of such entities. (Armstrong 1989, 7–8)

He is apparently committed to the view that all scientific explanation appeals only to causal entities. At the very least, he is challenging those who believe that abstract entities *do not* lack explanatory power, to demonstrate how this is possible. In the next two sections I will take up Armstrong's challenge. In section 2 I discuss the explanation of why stars do not collapse. I argue that in some cases the preferred explanation is not causal. In the following section, I discuss the explanation of why beams of light are apparently bent in the vicinity of massive objects. Again the preferred explanation is non-causal. Moreover, in this case, the explanation invokes acausal abstract entities (geometric entities).[3]

2. Stellar Stability

A star such as our sun is subject to tremendous gravitational forces, which drive all the matter of the star inwards towards the centre. What prevents a star from collapsing further? There are four cases to be considered.

The first is where a star is said to be in hydrostatic equilibrium. Here the gravitational force is trying to compress the star and this force is balanced by pressure from within the star. Most of this pressure is provided by the pressure of the gases themselves, although in very luminous stars radiation pressure is also a factor (Abell *et al*., 507). Here the explanation is clearly causal.

The next three cases are concerned with when the nuclear fuel[4] is largely used up and hydrostatic equilibrium is upset. Case two is where the star has a mass of about the same as our sun. Here, after another nuclear fusion reaction (the triple-alpha reaction), the gravitational forces take over and the star collapses down to another stable arrangement: the so-called white dwarf. The reason that a white dwarf does not collapse further is completely different from the previous case. The star cannot collapse further because of electron degeneracy.[5] Here there is no internal force counteracting gravity, and thus, it seems, no causal explanation.

The next two cases are similar to the second, except that the mass of the star in these cases is greater than the Chandrasekar mass limit of about 1.4 times the mass of the sun and so the electron degeneracy can be broken. The result depends on how much greater than 1.4 times the mass of the sun the mass happens to be. If it is somewhere between 1.4 and 2.0, the star is again prevented from further collapse by the Pauli exclusion principle; this time by neutron degeneracy.[6] The resultant star is called a neutron star since it consists largely of neutrons. Again the explanation for the

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[3] I discuss other examples in (Colyvan 1998). See also (Smart 1990).

[4] The "nuclear fuel" is hydrogen, which is converted to helium via the proton–proton chain, releasing large amounts of energy.

[5] The Pauli exclusion principle states that no two particles of the same spin can occupy the same energy state at the same time. A system in its lowest possible energy state thus has every energy level, from the lowest upwards, occupied by just one particle. Such a system is said to be *degenerate* and can collapse no further.

[6] The gravitational collapse is sufficient to force electrons to combine with protons to form neutrons, in what is essentially the reverse of radioactive β-decay.

collapse stopping seems non-causal. If, however, the mass of the star is greater than about 3 times the mass of the sun, neutron degeneracy is broken and the star continues to collapse to a black hole.

David Lewis considers this example, albeit in less detail, and concludes that in the cases where the collapse stops because of the Pauli exclusion principle:

> The state-space of physical possibilities gave out. (If ordinary space had boundaries, a similar example could be given in which ordinary space gives out and something stops at the edge.)
>
> [I]nformation about the causal history of the stopping has been provided, but it was information of an unexpectedly negative sort. It was the information that the stopping had no causes at all, except for all the causes of the collapse which was a precondition of the stopping. Negative information is still information. If you request information about arctic penguins, the best information I can give you is that there aren't any. (Lewis 1986, 222–223]

This reply seems rather odd though. The oddness stems from the conjunction of the assertion "the stopping had no causes at all" and the claim that this is a *causal* explanation.[7] There is only one way to make sense of this, and that is if Lewis really does see this case as analogous to that of ordinary space giving out. This analogy, however, seems entirely inappropriate since, as we have seen, the Pauli exclusion principle prevents stars *of certain masses* from collapsing further; it does not prohibit further collapse, simpliciter. Presumably if a white dwarf had a greater mass at the crucial second red giant stage its collapse would have continued.

The case seems more analogous to a person trying and failing to break a door open by charging it with their body. It is not that physical space has given out; it is just that the person's momentum isn't great enough. In the latter case a causal story of why the door couldn't be broken open can be provided in terms of the door providing a resisting force, and it is precisely the lack of such a story in cases two and three of the stellar collapse that makes them cases of non-causal explanation. In effect, I am denying that Lewis's causal story is a satisfactory explanation of the phenomenon, since it fails to give an account of what prevents some stars *and not others*, from collapsing down to more compact configurations. The non-causal explanation (i.e. appealing to the Pauli exclusion principle) has no such shortcoming.[8]

3. The Bending of Light

The path of a beam of light is bent in the vicinity of a massive object; the more massive the object, the greater the bending. What is the explanation for this bending?

The preferred explanation, offered by general relativity, is geometric. It's not that something causes the light to deviate from its usual path; it's simply that light travels along space-time geodesics and that the curvature of space-time is greater around

[7] For David Lewis a causal explanation is "the provision of information about causal histories" (Lewis 1986, 221).

[8] Assuming that the Pauli exclusion principle is not underwritten by a quantum hidden variable theory.

massive objects. The defender of causal explanations may suggest that it is the mass of the object that *causes* the curvature of space-time, and so there *is* an underlying causal explanation after all. There are two problems with this reply though. The first is the difficulty of spelling out, in a causally acceptably way, how it is that mass brings about the curvature of space-time. After all, it can't be that there is an exchange of energy and/or momentum between the object and space-time, as some accounts of causation require. I do not wish to commit to the details of a particular account of causation, but it seems that any account that permits mass to *cause* the curvature of space-time is unintuitive.

I acknowledge that there is undoubtedly covariance between mass and curvature, but I deny that all covariance need be cashed out in terms of causation. For example, the angle sum of a triangle covaries with the shape of the space in which it is embedded, but one is not inclined to say that the angle sum of a triangle *causes* the shape of the relevant space. It seems to me that the case of mass and the shape of space-time is similar to this. Another way of looking at this difficulty is by asking the question: Why is it not the case that the curvature of space-time causes the mass? Simple covariance doesn't guarantee that one of the factors causes the other.

The second problem for this line of argument is that there are solutions to the Einstein equation for empty space-times in which the curvature of space-time is not identically zero. These are the non-Minkowski vacuum solutions (Peat 1992, 17).[9] Thus we see that, at the very least, mass cannot be the *only* cause of curvature. What then is causing the curvature in the vacuum solutions case? There is nothing *to* cause it! Why then insist on a causal explanation of the curvature in universes *with* mass? I suggest that there is no reason at all, and that we ought to simply accept the geometric explanation for the bending of light.

4. Conclusion

These two examples show that there is more to scientific explanation than causal explanation. But they also demonstrate how acausal entities can explain the behaviour of physical systems. In light of such examples, Armstrong's argument for the causal test is in trouble, for Armstrong agrees that we have reason to posit entities that have explanatory power. If selective realists wish to invoke a causal test to distinguish denoting terms from non-denoting terms, a defence of such a test by appeal to the lack of explanatory power of abstract entities would seem misguided.[10]

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[9] The situation is somewhat complicated though, since the positive mass theorem of general relativity states, in effect, that such solutions must have a singularity, without which the space-time would be flat. This is assuming the ADM (global) conception of mass. Adopting the stress–energy tensor conception of mass (which is a *local* conception of mass), however, non-singular, non-Minkowski, vacuum solutions are possible. For example, the analytic extension of the Schwarzchild metric (d'Inverno 1992, 219–221) through the singularity has non-zero ADM mass but the stress-energy mass is everywhere zero. What is more, this space-time is non-singular and non-flat. Thanks to Robert Bartnik and Matthew Spillane for their help with this point.

[10] Graham Oddie (1982) also takes issue with Armstrong's causal test. His concerns are somewhat different to those discussed in the present paper, though.

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