Physics in the Hobbit
or
Did JRR Go Wrong?

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1 Introduction

Warner Brothers flagrantly defied the laws of physics, but were never arrested. I remember vividly the look of sheer doom and depression which overtakes the Coyoté's features in those moments before gravity takes its inevitable effect upon him, after the hapless fellow is ejected off an appropriately dramatic precipice. The effect was humourous, simply because we all knew how ridiculous the delay was, which emphasised his predicament, in addition to the drooping of his visage.

More often than not, however, such flagrant deviations from the physical reality annoy sensible audiences. Science fiction writers can get close to the wind, but woe betide one who breaks an immutable law without an excuse that common physical sense can't scotch on the spot. The biggest sin seems to be to portray such a deviance, and *not to acknowledge it.* A recent paper by Price[1] commenting upon Enid Blyton's subtle and insidious defiance of our laws began my wonderings upon how much I had been taken in by Tolkien. Price is a hydrogeologist, so you might expect his pickyness to be a tad specialised. I reproduce a small quote, to show that this is not so:

> What shocked me, may surprise others. It was not the supposedly implicit racialism in Blyton's characterisation of the Gollies in the Dark Wood. It was not the middle class prep-school background of the "good guys". It was not even the way that almost everyone from my own social background was portrayed as scruffy, unshaven, dim-witted, or with criminal tendencies. No, it was her treatment–perhaps I should say ill treatment–of geology and hydrogeology.
>
> In Blyton's world, all coastlines have islands, all island's have caves, all caves have a rocky ledge at the back where adventurous children can arrange stocks of tinned food. Most caves have a circular opening in the roof to provide a chimney, a skylight or another entrance–overgrown so the villains cannot find it; when the children find it by falling in, they don't hurt themselves because–oh, yes–all caves also have soft sandy floors.
>
> If all this seems improbable, then Blyton's next trick is impossible. Some of her islands are linked by systems of caves that are natural (except for a few rough steps added at each end), that run under the seabed and yet are completely dry. As the children walk along, listening breathlessly to the sea pounding above their heads, they don't even get

[1] Price, Michael, "Five rush into print–again", New Scientist, 2 July 1987

> their feet wet. I bet that the builders of the Channel Tunnel would like life to be that simple!

So herewith follows my own study of The Hobbit regarding its sensitivity of, and consistency with respect to, physics.

2 The Physics

2.1 Gandalf's Magic Light

The first potentially suspect instance occurs at the first usage of magic by Gandalf. He creates light from his staff.

> Gandalf struck a blue light on the end of his staff...[2]

Since even the dodgiest parlour trickster could emulate this, and Gandalf had devoted much of his extended life to the study of fires and such, we shall not dwell on this trivial thing.

2.2 The Invention of Golf

Shortly after, JRR explains that Old Took

> ...knocked their king Golfimbul's head clean off with a wooden club. It sailed a hundred yards through the air, and went down a rabbit-hole, and in this way the battle was won and the game of Golf invented at the same moment.[3]

This goes with the Coyoté's mode of descent, and it is less than certain that the description is taken as fact by anyone concerned. This may safely be disregarded as evidence that the Master goofed.

2.3 Smaug and the Passages under The Mountain

As the dwarves told it to Bilbo, Smaug killed, ate or otherwise disposed of their ancestors throughout the Mountain:

> Then [Smaug] went back and crept in through the Front Gate and routed out all the halls, and lanes, and tunnels, alleys, cellars, mansions, and passages. After that there were no dwarves left inside...[4]

Leaving aside the atrocious punctuation and excessive use of conjunctions, for which act it seems likely Dr Tolkien had a current licence, and which at any rate are not my concern here, there is some conflict with further descriptions which occur in the part where Bilbo ends his discussion with Smaug:

> ... the dragon spouted terrific flames after him... the ghastly head of Smaug was thrust against the opening behind. Luckily the whole head and jaws could not squeeze in...[5]

It is curious that the dragon who managed to purge every last dwarf from under the Mountain could not now persue one Hobbit from the main treasure chamber. We are *forced*[6] to assume that he had now grown to the point where he could no longer walk the halls of his domain. This is a thinnish excuse, especially as no mention of Smaug's being a small dragon occurs in the first descriptions, and the explanation I offer represents a narrow escape for the author.

2.4 The Troll Incident

> William... and Bert and Tom were stuck like rocks... And there they stand to this

[2] p16. Page references pertain to The Hobbit, twentieth impression, 1975, Unwin & Allen.

[3] p17

[4] p23

[5] p209

[6] by the desire to justify the works upon which this society is founded

> day, all alone, unless the birds perch on them; for trolls, as you probably know, must be underground before dawn, or they go back to the stuff of the mountains they are made of, and never move again.[7]

Clearly trolls are made of stuff that polymerises when exposed to ultra-violet radiation, along the lines of Acrifix.[8]

This story must rate along with Jules Verne's predictive works of fiction or H G Well's hopes. Only in recent times have the UV acryllic fixing agents, such as Acrifix used for bonding perspex, been available. Yet Tolkien describes the very mechanisms here.

It is worth noting here that Gandalf is not required to demonstrate any power in himself save knowledge. One might expect a work of the global inventiveness of Tolkien's Middle Earth series to need to have magic (as seen by the characters in the book) invoked frequently to bestow superiority upon a character. A search for physical anomalies might likewise expect to have to dwell extensively upon the acts of "magic users". Though individuals such as Gandalf and Beorn were so influential in the tides of beings in Middle Earth, their "supernaturality" will be seen to be subordinate to their natural strengths.

After the trolls were stoned, the party try to open the door to their lair. Gandalf

> tries various incantations.[9]

Nothing happens, until Bilbo provides the key to the door. There is no evidence that these actions of Gandalf move so much as one molecule. One cannot but imagine this scene giving rise to the overt trait of hammed-up faking found in the character of Gandalf as represented in "Bored of the Rings". No brownie points lost here, at least not for treatment of physics.

However, the narrative then comments on the key found by Bilbo:

> It must have fallen out of [William's] pocket, very luckily, before he was turned to stone.[10]

Here Tolkien could be seen to have blown it. We might have easily assumed that the beastie's clothes were not turned to stone as he was. However, it seems at once that the case must be that they were, else the key would have been accessible post-stoning. This conclusion and the implication that such implied violation of common-sense physics are both flawed.

The fact that the dropping was fortunate could stem from the fact that fallen, it was found by Bilbo who knew not even of the keyhole, let alone of any key; further, if the curious and powerful polymerising agent in trolls was secreted in their natural bodily fluids, the long-unwashed vestments of the trolls would certainly have been impregnated with it, and would have cured on exposure along with the creature. Again there is no forced contravention of the *laws*.

2.5 Moon-letters

These extra-ordinary things are described by Elrond as

> rune-letters... that can only be seen when the moon shines behind them, and what is more, with the more cunning sort it must be a moon of the same shape and season as the day when they were written.[11]

Through the premature snickers of unbelievers, I must hasten to explain that this phenomenon is to circular polarisation for us, as Acrifix would be to Tarzan's grip for our grandfathers. Let me explain this a little, as I am sure the unbeliever is rather "slow on the up-take", rather like a troll.

A few years ago, no-one would have believed that it would be possible to get two bits of slightly tinted plastic, and merely by rotating them with

[7] p38
[8] TM regd.
[9] p39
[10] p40
[11] p49

respect to each other, transform them from near transparency to thorough opaqueness. Yet polaroid filters do just this, and most schoolboys know it. They will also let you get a clear view of women swimming in glary pools, and most schoolboys know *this* too. Some people find it hard still to comprehend how two radio waves of the same frequency can get out of one antenna and into another without each having any effect upon the other, but differently circularly polarised ones do just this. I think, given Tolkien's insightful anticipation of photo-cured polymers, we can hardly but permit him the leeway of assuring us that there are as yet undiscovered properties of light which can be used to selectively betray certain selected chemicals, inadequately reflective or refractive to be perceived for their interference with normal light. A further piece of evidence is that the Dwarves were forced to use silver pens to write the runes, presumably as the conventional pen of the day could not handle the frighteningly sophistocated organic reagents I imagine to have been required in the ink.

2.6 Gandalf's Lightning

Surprised by goblins, Gandalf was awoken and

> ...when goblins came to grab him there was a terrific flash in the cave, a smell like gunpowder, and several of them fell dead.[12]

This is of the same level of technical wonder as the lighting of the staff which first occurred so early in the piece. If they knew the smell of gunpowder, it is not such a big step to know about shrapnel, magnesium flashes, and so forth. The fact that Gandalf delighted in, and was not unlearned at, pyromanial persuits is further evident at a point much later where Wargs and goblins wandered carelessly near the foot of a tree housing the wizard:

> He gathered the huge pine cones from the branches of his tree... set one alight with a blue fire and threw it whizzing down among the circle of wolves. Then came another and another... one in blue flames, one in red, another in green.[13]

He even seems to have collected assorted salts of potassium, copper and chromium.

2.7 Gandalf's Darkening

To show his skills with lights and fires were not mindless fireworkery alone, Gandalf tries another angle in the hold of the Great Goblin:

> Just at that moment all the lights in the cavern went out, and the great fire went off poof! into a tower of blue glowing smoke, right up to the roof, that scattered piercing white sparks all among the goblins.[14]

As anyone who has tried to increase the power of firecrackers (bungers) by binding several together will tell you, the explosion of the first tends to extinguish the later ones. The fire was most likely extinguished by the gunpowder used to propel suitable cinders. The great gust of blue smoke is suggestive of some special purpose, as simple powder does not generally make such a plume. My guess would be that the bomb responsible for the extinguishing blast was designed to expel ashes and cinders as added distraction.

2.8 Elven-blades

It is Gandalf who first brandishes the Eleven blade Glamdring the Foehammer in the caves where there was no natural light.

> He took out his sword again, and again it flashed in the dark by itself. It burned with a rage that made it gleam if goblins were about; now it was as bright as

[12] p55

[13] p95

[14] p59

> blue flame for delight in the killing of the great lord of the cave.

Further, to the credit of the most skillful Elven forge-masters of old

> It made no trouble whatever of cutting through the goblin-chains and setting all the prisoners free...[15]

That the blade was created of a material altogether stronger than mild steel is not stunning. Given the volcanic excesses portrayed in Lord of the Rings, it is not at all inconceivable that the Elves had the resources available and forged sophistocated carbon titanium laminar alloy materials. Even that these would glow in the dark is not beyond the realms of possibility. The fact that they would glow in the presence of goblins, and presumably not otherwise, *is* interesting.

The first and most simple theory is that the sword was activated to fluoresce by the chemicals in the blood of its victims. This approach, however, requires us to explain that it could glow in response to minute quantities of chemicals much like ants following pheromones, since this is all that could be expected to be present in the mere proximity of goblins. There is also some complexity in the mechanism, since the blade is not consumed at all in the glowing, and so must at worst be a catalyst.

I favour a more straightforward explanation, though one more unconventional. The energy emitted in the glow must be supplied by the goblins. These creatures, dwellers in the deep earth, were in all likelyhood quite radioactive. This would be an active survival trait in the species, since it would not only mean that they themselves would be unharmed in the presence of radio-isotopes, but their non-radio-carrying foes would suffer merely from proximity. Thus such a property would be likely to come about. The "recent" goblin (evolutionarily speaking) was, at the time of Bilbo's life, a complex factory for the concentration of radio-isotopic molecules. The sword merely contained in its diverse alloying agents one that fluoresced with extra-ordinary efficiency. Thus the Eleven-blade was as useful to the Middle Earth resident as would a Geiger counter be to you after an incident such as Chernobyl.

2.9 The One Ring

Tricky. It would seem that the effect of the ring is undeniably invisibility:

> The goblins stopped short. They could not see a sign of him. He had vanished.[16]

To add more constraints on any theory to explain this, it seems that the ring acted only when worn, and not only upon the body of the wearer, but upon his clothes. Worse, when Bilbo loses the buttons off his coat, they become visible again without him:

> [Bilbo] gave a terrific squirm. Buttons burst off in all directions... He was through... while bewildered goblins were still picking up his nice brass buttons on the doorstep.[17]

Two clues to unravel the conundrum are there. Firstly, he cast shadow, though not much of a shadow, as this quote from the goblin guards occurring as Bilbo squeezed out of the small crack in the door where he lost the buttons:

> ...one of the goblins shouted "There is a shadow by the door! Something is outside."[18]

Secondly, from the later work "Lord of the Rings"[19] we know that the invisibility was ineffective against another ring-wearer. This is a crucial clue.

Since the invisibility was not "operative" in the case of another ring-wearer regarding one using

[15] p60

[16] p82

[17] p83

[18] p83

[19] Book 1, "The Fellowship of The Ring"

Bilbo's ring, the invisibility cannot be real. Examine this evidence. We had only the *descriptions of what the goblins did not see* to lead us in our analysis of the ring's effect. If the invisibility was real, the wearer would not reflect photons of light. Another mechanism, such as provided by another ring, could not recover the photons if they were never reflected. One could construct complex theories of near-eliminated reflectivity and reduced refractivity, and then give the second ring-wearer hightened photo-perceptivity, but this line has a snag: Human eyes approach ideal sensitivity, converting almost all incident photons to neural signals, so the seeing of the so-called invisible would require active sensing (such as radar where the watcher emits the energy) or would violate conservation of mass-energy. No, the invisibility is merely a perception.

So how does it work? The watcher is convinced that the wearer is invisible, most likely by some telepathic effect. Perhaps the ring resonates in some critical way. This is a field where we have so little experience, I cannot hope to expound a complete effect, just as I cannot explain hypnotism. I am, however, at an equal loss to produce any evidence as to the general of the process.

2.10 The River in Mirkwood

While traversing Mirkwood, Bombur falls into the river, against which occurrence the party was warned, and

> ...when they laid him on the bank he was already fast asleep... and fast asleep he remained despite all they could do.[20]

Since this process so resembles anaesthesia, and since most of the substances involved in that process are of natural extraction, it is hardly worth going into an explanation. The mention of magic and such are a placebo for the technically uneducated.

[20] p134

2.11 Dreams & Lights in the Forest

I would not mention the matters of the dreams that the party had in Mirkwood when they first came across the Wood Elves, except for an interesting point. Several times

> ...a regular blaze of light...[21]

or

> ...feast... greater and more magnificent than before...

appeared as if by magic, but was quenched when they approached. This could be explained as trickery on the part of the elves, but is much more elegantly explained as part hallucination. The party was quite out of it, probably on the same sort of chemicals that affected Bombur from the stream. Once again the source of ideas for *Bored of the Rings,* (i.e., *The Hobbit*) is unmistakeable.

2.12 Fire-breathing

It is hardly worth searching out one or more of the quotes to remind the reader that Smaug breathes fire. The question is whether this constitutes a violation of physics. There is no question that animals produce combustible substances. The question is whether Smaug could be equipped with some reasonable ignition system and whether he could survive the fire-breathing rather than singing himself into oblivion at the first angry outburst.

Heaps of mouldering vegetable matter can spontaneously catch fire. It is to my mind not at all inconceivable that something with a much higher metabolic rate, such as an animal–even a reptile, could outdo hay at making fire. I doubt that Smaug kept fire inside himself, since that would likely result in a self-roasting process. However, he could easily (as many creatures do) rely on a symbiotic relationship with a few bugs

[21] p142

of the kind that are good at giving mankind a foul and flammable condition of the bowel. Some of these microbes which specialise in keeping odd bodily substances at the ready might easily generate the appropriate organic molecules, even if dragons did not have an appropriate gland themselves. Like glycerine, potassium permanganate and oxygen, these would provide fire upon exposure to air (oxygen), after the vigorous fashion of antimony in chlorine.

Since the true, full-scale burning would in this case occur in the turbulent zone just beyond his lips, only a few scales at the front would get severe thermal exposure. These are easily accepted as reasonably fire-proof. No, Smaug does not violate the laws of physics, though he does indeed push the limits of probability fairly far.

2.13 Magic Portal Hold

When the dwarves brought their mining tools to bear upon the portal at the doorstep of the secret rear entrance to the mountain,

> ...they struck the stone... the handles splintered and jarred their arms cruelly, and the steel heads broke or bent like lead. Mining work they saw clearly was no good against the magic that had shut this door;[22]

Bullweevils. The door was in all fairness very well made indeed, but it was they who couldn't open the door, because they were simply not up to it. Whoever heard of picks bending, anyway? They might get a bit blunt, but I can't see a dwarf bending a decent pick head. Blame their tools if you like, but don't give me this magic stuff. [As a matter of fact, I'm getting sick of the level of fraud in this book. Everybody's a crook, or a thief, or a trickster....]

[22] p191

2.14 Smaug and Bridges

Precisely what facet of geography or topology gave rise to Smaug's reaction upon reaching Laketown, I cannot at once envisage:

> Amid shrieks and shouts of men he came over them, swept towards the bridges and was foiled! The bridge was gone, and his enemies were on an island in deep water–too deep and dark and cool for his liking. If he plunged into it... it would quench him before he could pass through.[23]

As if Smaug was expecting to waltz across the bridge so recently cut down, he is upset by its absence. Odd is this, as he could not fit passages of the mountain by now, and yet he could (and did) fly over the roof work of Laketown and set it adequately alight thus. Perhaps he would have preferred to walk, fearing the consequences of a small miscalculation in flight. I fancy he would have been more unsafe walking the enclosed halls of a town burning off its supports over the lake, about to sink. We must assume that he was momentarily not thinking, gripped with rage in place of common sense, or contrary to expectations, just a schmuck.

2.15 The Serious Inconsistency of Bilbo's Thoughts

Though my brief was physics, not general consistency, there does appear to be a severe mismanagement of information, the resolution of which would demand the transfer of information from one mind to another, a thing not claimed at all.

As Bard came to speak with Thorin under his mountain, Bilbo thinks:

> [Bilbo] did not, of course, expect that anyone would remember that it was he who discovered all by himself the

[23] p227

> dragon's weak spot; and that was just as well, for no-one did.[24]

The problem is that Bilbo did not know that it was the knowledge of Smaug's weak spot that had felled him.

Oops.

3 Conclusion

Price stated in his article

> Even that master storyteller J. R. R. Tolkien had some funny ideas about volcanoes, but, because Tolkien's world–as well as his characters–was an invention, he arguably deserved more licence than most.

I am inclined to favour that view. I certainly cannot find it even in my picky nature to reject this work on grounds of bad physics, as I would cast out some science fiction book that claimed to paint a picture of some private world and yet permitted unexcused gross distortions of nature.

I do think, however, that it is in spots logically limp, and asks much of the reader, not in a physical sense, but in one of consistency. Let us not deify the professor so much for his precision as his imagination.

[24] p242