

REFERENCE FRAME

Illuminating the Obscure

Roger D. Blandford



Last Friday, I was having a drink with a group of radio astronomers outside the Caltech Faculty Club, enjoying the fading light of a cool evening. In the course of a meandering conversation, I mentioned that I had made a gift of Umberto Eco's novel, *The Name of the Rose*, to our former departmental librarian. (It is, as many readers will know, a rattling yarn of scholarly intrigue and violent death, and it culminates with the burning of an entire library—a gift that could be safely proffered only upon her permanent and irrevocable retirement.) Now, radio astronomers, collectively, affect an air of muscular Philistinism and so we were all slightly surprised to find out that everyone around the table had read and enjoyed the book and, what is more, several of us had tackled Eco's rambling sequel (perhaps because it was called, almost irrelevantly, *Foucault's Pendulum*), as well as his latest offering, *The Island of the Day Before*, with its lyrical examination of longitude, and his amusing essays on semiotics and popular culture. So much for self image among radio astronomers.

Anyway, inspired by this conversation, I returned home and took down *The Name of the Rose*, for the first time in many years, and started reading it again. The hero is a fictional protégé of Roger Bacon and a steady voice of moderation and tolerance in an age when bands of ill-educated, though fervent, heretics—Cathars, Bogomils, Waldensians, Apostolics and so on—roamed Europe in fear of “cleansing” by the self-appointed forces of law and order. What struck me this time around was neither the grafting of modern scientific inquiry onto a medieval mind, nor, indeed, the shameful parallels with modern European history, but, instead, the heresies themselves. So I started to read more about them.

Although they had evolved considerably, many of these sects were spiritually derived from Manichaeism, a religious movement founded by the Parthian mystic, Mani, in the third century AD. It was a fusion of Christian theology with the Persian concept

of dualism, and held that the Universe was formed as a mixture of light and dark stuff, representing good and evil, and that the kingdom of light was trying to escape from the kingdom of darkness. Manichaeism is an elaborate cosmology, a history of the world in three acts. In the first act, the five, personified elements—light, wind, fire, water and breath—which emerge from the substance of Paradise, are overwhelmed by the powers of darkness. However they are able to regroup and, in the second act, inert earths and heavens are fashioned. The third act is the story of life, created through a sequence of racy unions. Living bodies contain both dark and light and once more, the light strives to escape, this time to the column of glory (the Milky Way) via the waxing and waning moon and the sun.

Although, as a strict theology, Manichaeism died out in the middle ages, the juxtaposition of light and dark was an enduring literary and cultural theme. Dante's divine journey took him from the dark forest to the radiance of paradise. The theme was a common motif in Shakespeare's work: for example, “Light seeking light doth light of light beguile: So, ere you find where light in darkness lies, Your light grows dark by losing of your eyes.” It crops up in painting as chiaroscuro. It persists to this day in countless forms, for example as film noir or, most appropriately, the plots of the Star Wars movies.

By now, this should sound familiar. In 1933, the astronomer Fritz Zwicky measured the relative velocities of a large number of galaxies collected in a rich cluster and, using a simple application of Newton's laws, was able to deduce that there was far more mass present than could be accounted for by

all of the stars that he could see. In modern language, he discovered that clusters of galaxies are formed in giant gravitational potential wells that are shaped by a mysterious substance that only appears to interact with normal material, and itself, through its gravitational field. We now call this substance “dark matter.” It is not just present in galaxy clusters; as far as we can tell, the outer parts of individual galaxies such as our own are dominated by dark matter and the universe on the largest scale is mostly dark. Now, as physicists and astronomers, our first concern is to identify this alien substance. It may well take the form of elementary particles, like axions. Conceivably (though improbably, in my view), it could be a population of black holes, and that is about as dark as you can get. Whatever it is, it can maintain its structure and it is responsible for the architecture of the modern universe, while the baryons, our stuff, can radiate away heat and collapse to form successive galaxies, stars, planets and life.

So, we too believe that the kingdom of light is originally trapped and struggles to free itself from the kingdom of darkness. As I explored further the details of Manichaean theology, it became a remarkable allegory for contemporary physical cosmology. Are the five “bright” elements really baryons, photons, and three neutrinos or is this the first reference to quintessence? Wasn't I reading poetic descriptions of symmetry breaking, baryogenesis and decoupling? Don't I catch a whiff of Darwinian evolution in the tales and taxonomy of sea monsters and demons? Indeed, I caught myself wondering if modern cosmology was an allegory for the true faith of the Manichees!

So where is this leading? Am I really trying to persuade you that Mani anticipated axions? Of course not. Not even Zwicky would have claimed that. Do I think that modern Manichaeans should be slowly roasted at the stake? Despite the hubris exhibited by certain of my colleagues, this punishment does seem excessive. Am I cautioning, more simply, that the theory of cold dark matter is just plain wrong? After all, St. Augustine, who was a reformed Manichaean, described his former associates as “frauds who deceived both themselves and others

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and, for all their talk, were no better than mutes." No, I'm not even saying this because, objectively, the circumstantial evidence for dark matter is pretty impressive even if it does not quite flatten the universe. Instead, what I am trying to illustrate is that even idle associations at the end of a busy week can connect physics and astronomy in interesting ways to a much greater, and largely nonscientific, culture that we all share.

I wonder if too many of us are reluctant to undertake these explorations. There is no good reason why we should be. After all, we have pride and confidence in our science, and understand how it rests upon strata of reproducible, quantitative measurements that retain their integrity through quakes, uplift and folding, and that these strata are continually being covered by fresh deposits, some of which will form new strata while the detritus is fated to be washed away to the ocean of forgotten ideas and bad data. Physics and astronomy are, for the most part, a constructive activity and established, empirical facts do not change. The value of the fine structure constant and the Lorentz transformation are not matters of opinion, and there is no great need to become unhinged if a small minority of our colleagues in other academic disciplines claim otherwise. We should be far more concerned about those who may be too ignorant or too intimidated to think anything. Besides, would we want to be held personally accountable for the silliest, or even the median paper in *Astrophysical Journal* or *Physical Review*?

There is really nothing particularly new here. Physics is full of such connections ranging from amusing, literary allusions like quarks or calling a paper on the spectrum of tensorial fluctuations in the early universe *Gravity's Rainbow* to serious examinations of the relationship of science to art, music and literature. From my own field of astrophysics, perhaps the most inspiring views are those of the late Subrahmanyan Chandrasekhar. In his collected essays, *Truth and Beauty*, he thoughtfully contrasted supreme accomplishments in physics, literature and music. He brought his customary scholarship to bear on the issue, displaying a fine sensibility and showing how these endeavors can illuminate each other. However, he never lost sight of the fact that writing verse and solving equations are two fundamentally different activities. (Incidentally, anyone who suspects that these extra-scientific excursions led to a softening of Chandrasekhar's brain is invited to work through chapter nine of another monograph, *The Mathemati-*

cal Theory of Black Holes.)

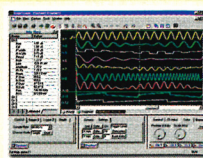
Physical scientists are constantly admonished to make their craft more accessible to nonscientists. More often than not, though, we fail at this task because we are prepared to speak only the uncompromising language of physics, making methodological assumptions that are quite foreign to many of those with whom we are trying to communicate. However, there are two quite separate reasons why we must not fail. First, many of those who are charged with making far-reaching, yet difficult decisions about technical questions ranging from energy and environmental policy to nuclear weaponry do so in alarming ignorance of what is actually involved. This is dangerous. Second, society at large has become highly dependent upon the fruit of technology, be it medical imaging or personal computers, whose functioning is, for most users, indistinguishable from magic. This is fundamentally undemocratic. It empowers the priesthood that creates and operates these utilities in a way that is no less disturbing than what happened back in the middle ages.

All of this brings me back to my drinking companions. While few of us physicists and astronomers would care to be measured against Chandrasekhar, it has been my pleasant experience to discover that we are more broadly and eclectically educated than we sometimes care to admit. (This is not, I hasten to add, a result of superior intelligence, fine schooling or earnest self-improvement, but derives from simple curiosity—the most precious legacy of a traditional physics education. We fear nothing!) I contend that we are relatively well-prepared to engage in a dialog with nonscientists and that we should take more initiative in trying to go beyond conventional popularization or science fiction and to explore actively the territory between the worlds of numbers and letters. (Don't expect this to be easy, though. The only time I attempted to quote a living poet in a scientific paper, I dutifully requested permission and he responded that he couldn't understand a word of what I had written and that I owed him \$150!) However, even though my example of the common elements in Manichaeism and modern cosmology is more whimsical than profound, I did field test it on a few nonscientist friends and they started asking questions that I doubt would have followed a patient exposition of the virial theorem. Might not similar initiatives infect a few more imaginations? Furthermore, could exploring such connections actually enhance rather than compromise our own appreciation of what we do? I would like to think so. ■

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