Corrected: Author Correction

Old news on quasar viscosity

To the Editor — Much of the active galactic nuclei and quasar community has been fixated on a particular model for the energetically dominant 'Big Blue Bump' component of the spectral energy distribution for the past 40 years[1,2], despite the fact that the model is qualitatively incorrect. It's a 'quasi-static' model, meaning that flow of matter through the disk is steady on human timescales, except for the very lowest luminosity cases, with gas elements migrating through a geometrically thin accretion disk towards the black hole; the rate is constant over periods that are long compared with any other timescale in the problem, or a human lifetime. But empirically, variations in flux were known to occur on timescales of weeks to months, nearly in phase throughout the optical and ultraviolet regions, so cognitive dissonance was a part of the theory from the get-go.

In a recent Comment titled 'Quasar viscosity crisis', Andy Lawrence[3] points out that the variability properties of quasars rule out the model. Enough was known about quasar variability to preclude application of the model at the time it was proposed, and the failings of the model were decisively documented and explained by Alloin et al.[4]. The new variability data alluded to in Lawrence's article are immaterial; the arguments made in many papers over the decades, starting with Alloin et al., were robust, with orders of magnitude to spare. Hence, although Lawrence was correct[3], he wasn't reporting any news. It would have been news in the early 1980s.

The situation is a little bit worse, actually, in that Lawrence[3] emphasizes that the new reports he highlights tracked the optical-band emission specifically, which is expected to vary even more slowly than the ultraviolet. But we showed[5] even before the work of Alloin et al.[4] that optical emission from the nucleus of the Seyfert NGC 4151 had varied and was down to an undetectable level at some epochs.

There is no disagreement on the science, but the record needs to be corrected. In an essay[6] written for the 50th anniversary of the discovery of quasars, I pointed out other very fundamental falsifications of the quasi-static disk model from the literature, some of which date back 30 years. In our field, theories are often falsified before publication; observers present their data in the context of debunked theories. And, of course, every generation makes the same discoveries over and over again. These arguments include the lack of the expected relationships of spectral energy distributions with mass and luminosity[7,8], both at single epochs and in difference-spectra (high state minus low state, which is crucial). And there's the wee fact that gravitational microlensing mandates surface brightnesses (and hence thermodynamic emissivities) an order of magnitude below the theoretically expected value. Almost no one in the theory community tries to match that, and very few cite the sad fact, an exception being a toy model[9].

The culture is the same in most of the X-ray community. There, a seeming breakthrough was announced[10]: a four-day exposure taken by the Advanced Satellite for Cosmology and Astrophysics seemed to show an asymmetric horned profile — known as the signature of the Kerr metric — for the iron K-alpha fluorescence line. This paper was immediately followed by a closer look at the same data[11], broken into segments. It turns out that the magic profile never appears at a single epoch, but only in the four-day sum, so that if the observers had been given two days or eight days of observing time, the feature would not have appeared. This second paper presents the totally unexpected variability properties and then shows that with just a few more epicycles, everything works out fine.

The accepted geometry for an accretion disk is a thin, completely passive reprocessing disk on which stand upper and lower lampposts emitting X-ray continuum. Modellers routinely use thin disks for objects accreting at orders of magnitude above the Eddington limit[12]; they invoke fantastic and sometimes internally inconsistent iron abundances[12]. They ignore pesky things like the emission from the far side of the putative disks, even when inner gaps are employed and gravitational focusing causes the far-side emission to dominate the spectra[13].

Spin measurements completely rely on the assumption that the disks go from opaque to transparent instantaneously at the innermost stable circular orbit[13]. The lamps ride up and down as needed to scramble expected but unseen reverberation signals (how well this actually works is discussed in ref. [14] among others), they can move in radius and in azimuth as needed, and you don't even have to put in the general relativity effects which Einstein would have thought belonged there[13]. Sometimes the lamps can even hover above the disk if a part of the profile lasts longer than a dynamical time (so, to be precise, it's a 'disk drive' model). Critiques of reverberation and scattering models get short shrift[15] (indeed ref. [15] refutes the 'clinching' article[16] and accompanying celebratory commentary[17] on the unambiguous estimation of the spin of the black hole residing at the centre of NGC 1365).

While the cycle of news — as the name implies — is circular, our community cannot afford (in the literal sense of real-world cost) to forget (or even worse, disregard) important results that were already established decades ago. The maturity of our tools (both theoretical and observational) creates the scientific impetus for our community to go beyond simplifying assumptions about the accretion disks and tackle the problem head-on.

Robert Antonucci
Department of Physics, University of California, Santa Barbara, CA, USA.
e-mail: antonucci@physics.ucsb.edu

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