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Dear Jim:

I appreciate how perplexing it must be to watch from a distance as Ed Bertschinger and I appear to be working steadily without producing for you a finished manuscript of the second edition of *Exploring Black Holes*.

Only in the past ten days have I understood the stages we have gone through since Ed and I began to collaborate on the second edition. The delay is not from laziness: Almost every day I spend six or more hours working on the manuscript. The explanation, I now realize, is a series of phases in the revision, each phase requiring an extensive rewrite of the text.

PHASE I: EXPANSION AND CORRECTION. You can almost make this up: At the beginning, Ed and I assumed that we would leave most of the first edition in its original form, simply updating it and adding some current topics. Of course, we soon found that our (mostly Ed's) new insights required a thorough revision of the old, along with creation of the new.

I came to admire Ed Bertschinger's use of the exclamation "FALSE!" that he scribbled in many a margin of the new version. Nothing vindictive about this, just a statement of fact, delivered without the least antagonism. God knows I still have misconceptions, but most of the central errors seem to be under control.

PHASE II. THE DARK SIDE OF GENERAL COVARIANCE. This one is a bit technical: A basic assumption of general relativity, called *general covariance*, says that we can use (almost) any coordinate system we want to describe spacetime around a black hole. Nature does not care at all what coordinates we use. But this leads to a hitch: Our arbitrarily-chosen coordinates have no necessary relation to actual measurement. In analogy, print your road map of California on a rubber sheet and stretch it this way and that; the stretched map is still topologically correct, but not much use in measuring the number of miles between San Francisco and LA.

How can we predict actual measurements from general relativity (expressed in arbitrary coordinates) and use these predictions to describe the Universe around us? One of the few conditions for global coordinates is that they be "smooth." "Smooth" means that on a small enough patch spacetime is effectively flat. (Think of the perfectly useful standard flat road map of Kansas, a state that actually curves with the surface of Earth.) "Locally flat" means that an observer on every such little patch can use special relativity, which works only in flat spacetime. Everyone knows how to make measurements using special relativity. The

outcome is that in our book we make every measurement on a local flat patch, where special relativity rules. Every paragraph that describes measurement requires revision, now mostly done.

PHASE III. "SCIENCE FICTION WITH NUMBERS." Recently, Ed Bertschinger, who is Head of the MIT Physics Department, asked me to give a talk on our project to the weekly MIT Physics Faculty Luncheon. While preparing this talk, I realized that the central theme of our text is basically a powerful narrative: science fiction with numbers. This story line has been implicit from the beginning, starting with the title itself (*Exploring Black Holes*) and extending, for example, to a description of what you would see and feel during your fall from a great distance to the center of a black hole. Framing the text as a story brings warmth and immediacy to an otherwise clinical treatment. Almost every paragraph benefits from this focus. So a third careful rewrite is in midstream.

Your questions may be, "Have these jokers gone off the deep end? Will the result be commercial, acceptable to the profession?" You tell me: Pearson Science, Addison Wesley is our professional consultant here. On the one hand, I have not seen anything like it on the market. On the other hand, we stay close to the professional base:

1. Every general relativist is well aware of the technical content of Phases I and II. We are not changing traditional general relativity in any way. We may take the standard content to a new place, but the professional will recognize that place as home.
2. To me, John Wheeler was a demi-god; he stands at my shoulder every day. Ed Bertschinger is an absolute master of the subject, with a gritty determination to say nothing wrong. Between these two, the second edition will not stray far from the professional center of general relativity.

Soren Kirkegaard wrote, "Philosophy is perfectly right in saying that life must be understood backward. But then one forgets the other clause---that it must be lived forward." The recent retrospective clarity is reassuring to me; more exciting is where this path is leading.

You may share this analysis with anyone you think might be interested.

Best regards, Edwin Taylor

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