A Modest Proposal for the Future of Astronomy and Astrophysics

Over the past two decades Astronomy has appeared to make great progress. A long time ago it was suggested by Stirling Colgate that Type Ia supernovae (SNe Ia) – those with no obvious lines of hydrogen or helium – might be used as standard luminosity candles to determine the vast distances of their host galaxies which, along with their redshifts, could be used to determine the kind of Universe we live in (its cosmology). This speculation depended on a model of Type Ia SNe, proposed by the late John Whelan, wherein a white dwarf was pushed beyond the Chandrasekhar limit, near 1.4 M solar masses, by accretion of hydrogen from a more normal binary companion star which is expanding as it evolves. There is a long list of reasons why this idea is invalid, not the least of which is that no trace of hydrogen, which should have been advected from the mass-donating star by the SN explosion, has ever been found in their spectra.

By the 1990s, Type Ia supernovae were found to have a range of luminosities, depending on how much ^{56}Ni they produced (which would then produce positrons by decay, which in turn annihilate with electrons, producing gamma-rays which then heat the expanding remnant). Then in 1993 Mark Phillips took a handful of recently well studied SNe Ia, and with them showed that a direct relation might exist between the time it took for them to fade by a certain percentage in blue light, and their luminosity (W-L). However, exploiting traits of something that you don't understand (supernovae -- SN), in order to achieve other ends (determination of a cosmology), is one of the definitions of bad science, first pointed out to me in 1994 by my late colleague, Jerry Kristian. Nevertheless, CTIO, with the then largest telescope at a decent southern site, put the study of SN 1987A, which at that time was struggling with a promising candidate, on waivers after 1993, and concentrated on this dubious effort in cosmology. Astronomers are a desperate lot, unable to perform experiments on their subjects, and can only observe them. Sometimes bad science is the only option open, but sometimes it catches up with you, and in this case, it did.

Two production-level SN search efforts were just then coming online, collaborations directed from UC Berkeley and Harvard with overlapping observers, and the first results were ready within a few years. Because few SNe were known prior to these searches, the SNe Ia that Phillips used to determine the W-L relation were among the brightest. Soon it became apparent that distant SNe of both efforts were anomalously dim, which appeared to disagree with all previously conceived notions. *Still* no one understood what a supernova was. The two samples could easily have suffered from the same systematic effect – that the local sample might be too bright. At that time this local sample was small, and it would take a long while for it to grow.

Nevertheless, both teams invoked what has come to be known the Standard Model of Cosmology, including "Dark Energy" as a cosmological constant explaining the anomalous dimming via an accelerated expansion of the Universe, and another old, but still radical term, "Dark Matter," originally introduced in the 1930's by Jan Oort and Fritz Zwicky to account for the more-than-Keplerian velocities of stars in the arms of our Milky Way galaxy, and of whole galaxies within clusters.

Dark matter and energy were recently invoked mostly because the contributions to the overall closure density of the Universe, ~0.72 and ~0.24 nearly add up to unity, and do more exactly, when the 0.04 – 0.05 of ordinary matter that we know about, is included. Additional motivation came from computer simulations which failed to form star clusters without adding in a certain amount of dark matter. However this latter was the easiest, most expedient thing to do, since the programmer could just stick it in and turn the computational crank, just as was done with ordinary matter. And that's all it was. Fortunately, there is a much more physically acceptable alternative to explain star cluster formation (see below). Without this requirement, dark matter has by now outlived its usefulness, as galaxies in clusters are formed while falling in from a much greater distance than the size of their host clusters today, and spirals are always adding material from streams, so what appears to be unbound now eventually becomes bound.

Unfortunately, as observations of SNe Ia continued at a furious pace, the Standard Model of Cosmology gained further acceptance. However, by 2004 (and publications in 2005) it became clear that the SNe Ia which obeyed the W-L relation, from which the local sample was exclusively defined, occupied the brighter end of the luminosity function, and the fainter ones dropped off the end of the W-L relation. And because no one *even then* understood what a SN was, there was no way to exclude these from the distant sample – in effect explaining the anomalous dimming in its entirety, with no need for dark energy whatsoever.

What breathed life into what should have by then been a dead Standard Model of Cosmology were the results from WMAP, which confirmed the total density of the Universe at the time of recombination to be 1.00, with an error of a few 0.01. This resuscitation shouldn't have worked, as this number could be 0.9999992 at recombination, but diverges from unity as $1/(1 + \text{redshift})^2$ decreasing from $\sim 1/(1{,}100)^2$ then, to 1 now, for the density to end up as 0.05 today. This missing nearly one part per million at recombination may lead to a physical discovery, yet no one is following this thread of investigation.

So the SM continued on its undead way, sucking the life out of investigations more firmly rooted in physics. The NSF breathed yet more life into the SM by institutionalizing it in their grant process. The DOE followed suit about a year later, both efforts for the sake of featherbedding scientists whose skills and methods did not pan out. If anyone has any doubt as to the outcome of these efforts, the take on the Santa Barbara supernova meeting by Tom Siegfried in the April 13th 2007 issue of *Science* should put them to rest. "Yeah, they're all over the map," said one astronomer, who is also in the picture for the 2011 Nobel Prize awarded to this effort.

We are now nearing the end of 2013, and the cosmology effort from SNe has been scientifically bankrupt for two decades, going from bad to worse, and this will likely continue into the indefinite future unless we do something. Dark energy surveys continue to chew up dark *observing time* at the large telescopes because some astronomers still like to image galaxies, even though the chance of figuring out exactly what causes star clusters to begin to form and diverge from each other, at times very much earlier than those during which they can ever hope

to record images, is pretty small. No thirty meter telescope is going to change this, but there is the possibility of working the problem from the other direction of time (see below).

Fortunately, there is a (perhaps, for some, not emotionally) easy alternative. Starting in 1994 an elegant, and by all recent tests, valid, model of pulsar emission was developed by Houshang Ardavan of Cambridge University. The key concept was the induction of polarization currents in an annulus of radius, R, by the non-aligned magnetic dipole of a neutron star rotating at frequency Ω, in the plasma beyond the speed of light cylinder ($\Omega R>c$, where c is the speed of light), where these currents would be *updated* faster than the speed of light (a *supraluminal* excitation). The outcome of this process are beams of radiation, with polar angles of arcsin(c/v), where $v=\Omega R$ is the update velocity for the currents in any particular annulus of plasma, whose intensity diminishes *only as 1/distance* (a violation of the inverse square law physically allowable only because each of two arcsin(c/v) circles has zero solid angle).

It is then relatively simple to deduce how a SN disrupts its progenitor star. The beams, from all the annuli within plasma, accelerate and transmute matter in the progenitor, in the case of SNe Ia transforming C and O into Mg, Si, and S, and then eventually ^{44}Ti, ^{56}Ni, and even isotopes of Zinc, which are necessary to explain their natural abundances. In addition to the ^{56}Ni produced, the plasma annuli closest to the stellar center, with the lower v's>c, help to lift material away from the nascent neutron star (born with a magnetic field of a few billion gauss and spinning near $\Omega=2\pi*500$ due to the merger of two ~0.7 solar mass carbon-oxygen stellar cores for all SNe Ia). However, the plasma annuli much farther out, with v>>c, concentrate much of their energy (in ~500 Hz pulsations) at the stellar rotational poles, where the polar material is ejected with mildly relativistic velocities.

Because of the merger process for SN Ia progenitors, there is frequently material previously ejected from their poles, with a velocity of a few 10 km/s, which the pulsed radiation from the SN impacts after a few days. This becomes a volume source in scattered gamma-rays, within which supraluminal excitations occur, resulting in gamma-ray bursts for certain directions, generally close to the neutron star rotation axis, due to the associated 1/distance law. It then also becomes clear that the 1/distance law for the continued pulsations result in an optical/near-infrared afterglow close to the direction of the gamma-ray burst. Studies of SN 1987A show the radiation and jets of material particles eventually bunch up the polar ejecta into a luminous lump (the "Mystery Spot") whose velocity diminishes to ~0.3 c as more material is swept up. Such beams, jets, and lumps are the most likely sources to destroy enough entropy across interstellar space so that star clusters can form without any need of dark matter.

The ~500 Hz initial spin frequency is likely to be a standard because there is always too much angular momentum in the two-core merger process. Thus gamma-ray burst afterglows might be used to determine the redshift of the SN event, with redshifts of the host galaxies for the less distant events confirming and calibrating the relation. Although Jerry Kristian once said to me, "Imaging is everything in Cosmology," if one looks back far enough, only sources which violate

the inverse square law will be visible, in which case imaging is *almost nothing* in Cosmology -- neither the underlying SN itself, nor its host galaxy is likely to be visible. Thus GRB afterglow redshifts can be used to do cosmology at a distance when no other object or process is visible. Moreover, even though merger-SNe pulsars are still likely to numerically dominate pulsars resulting from massive, solitary stars, even those of the very first stars formed, some of the latter may also have visible-IR afterglows, albeit with about a six times lower pulsed frequency (but possibly no associated GRB).

The biggest problem with this effort is that observatories, thinking, in their not-very-infinite wisdom, that they'd never need them again, have discarded the very instruments (the fast ones) which could be used to do this, simply because they couldn't be bothered to *store* them. Fortunately, replacing them costs nothing in comparison to that of the (time-integrating) cameras and spectrographs that dominate the field. The next problem is that the current precision locator spacecraft for GRBs, *Swift*, produces only one instantly accessible afterglow, initially brighter than visual magnitude 16.7, every 60 nights. However, at least one competent investigator has proposed an instrument, in the *Swift* AO cycle, which would have been 10 times as productive. This would mean a bright, instantly accessible GRB afterglow every 6 nights for almost every observatory on the planet, and nearly one fainter afterglow, accessible to larger telescopes, *every night*, since *Swift* now produces eight GRBs every month, four of which have afterglows.

Not only do the 1/distance objects not need wide-field-imaging instruments, but even spectrographs will be useless. This is because objects which violate the inverse square law do so because they are *focused in time*. Thus only emission lines, associated with pulsed radiation, which recombine on timescales much shorter than a millisecond, will be similarly focused in time. One simply can't see into such material in the optical or infrared. In addition, absorption lines will be spread over the spectrum due to their relativistic velocities, but one can use GRB afterglows to backlight the Lyman α forest (though without time resolution, you can't measure the gap in redshift between the GRB and the first galaxies of the forest).

After a few years of this effort, we should have about a thousand redshifts, and a good idea about the ratio between merger and solitary SNe in the early Universe, as well as the cosmology of the Universe in which we live. Never in the history of Astronomy has there been such a class of objects just waiting to be exploited for such little effort and cost. The scientific payoff includes the supernova process, pulsar birth, gamma-ray bursts, pulsar-driven SN jets which obviate any need for dark matter, and the cosmology that all of these can yield. The current 17-year-old effort with GRB afterglows using the ever-popular time-integrating detectors has produced only intricate misunderstanding. One of the most notable of these has been the inference of Lorentz gamma factors in the hundreds, while studies of the jets of SN 1987A and Sco X-1 show that the fastest components move at just over 0.95 c. This proposed effort will be much more solidly rooted in the actual physics, and help to bring this sometimes otherwise miserable excuse for a science firmly into the 21st century.