CORRESPONDENCE

To the Editors of 'The Observatory'

Public Reaction to a $V = -12{\cdot}5$ Supernova

Imagine reading this page at night. By starlight. It could happen. What would be the effect today, on humankind, of a supernova having an apparent magnitude equal to $-12{\cdot}5$, roughly equivalent to that of the Full Moon? No one has recorded such a spectacle in historic times (meaning the last few thousand years in the northern hemisphere and the last few hundred in the southern). Looking to the future, the event is unlikely in any one human lifetime but inevitable on longer time scales.

Before tackling this question, though, it is necessary to address another: can a Galactic supernova be spectacular without producing such extreme physical effects that no person will care about the psychological and cultural effects? Both ionizing radiation and relativistic particles are unhealthy in large quantities.

As Ruderman pointed out[1] in 1974, the most probable life-threatening effect of a supernova would be depletion of the Earth's ozone layer by high-energy electromagnetic radiation. This scenario would subject the Earth to a huge increase in solar UV flux. Refinement of Ruderman's model by Ellis & Schramm[2] and by Gehrels *et al.*[3] established a 'kill radius', at which nominal atmospheric ozone is halved, equal to 8 pc. (Fields *et al.* further showed that a supernova at 10–20 pc may collapse the heliosphere to less than 1 AU in radius, thus subjecting the Earth to particle radiation as well.[4]) On the other hand, Thomas and colleagues demonstrated that ozone depletion is only equal to ten percent at a supernova distance of 30 pc, and that this depletion is short lasting[5]. Clearly, the social and psychological effects of a supernova — the topic of this letter — are made more-or-less irrelevant by physical effects at some supernova distance between 10 and 20 pc. Let us assume, for the purpose of this discussion, that our hypothetical supernova is far enough away so as *not* to toast the Earth (> 30 pc).

On the other hand, supernovae reach absolute visual magnitudes of approximately −18 (depending upon the type). Thus, $V = -12^{\mathrm{m}}{\cdot}5$ corresponds to distances from 100 pc to 160 pc. Millions of cubic parsecs occupy a volume between a radius of 30 pc and these outer limits (in which ordinary interstellar absorption, at one magnitude per kiloparsec, normally will be unimportant). This volume is mostly within the Galactic disc, where massive stars — relevant in the case of core-collapse supernovae, the more common sort — are concentrated. (Nuclear-detonation supernovae probably belong to a less disc-concentrated population.)

Are there candidates in hand? Yes: Antares and Betelgeuse are both M supergiants at about 120 pc and 150 pc, respectively. Their position on the H–R diagram strongly suggests that they have completed core hydrogen fusion and so have future life expectancies considerably less than their 10^7 year total life spans. Indeed, Beatrice Tinsley long ago suggested that both have begun carbon fusion and so might not have more than about 10^4 years to go. Beyond that, one cannot say, for after carbon ignition, stellar atmospheres do not have time to respond to changes in central conditions. Implied is that there is a one percent probability of core collapse in the next one hundred years.

Other recently advertised SN progenitors include T Pyx (for a Ia type event) and η Carinae. Both, though, are at kiloparsec distances, leading to an expected light maximum of perhaps $V = -9^{m}$ (more like a quarter Moon).

Reiterating, casual observers will see only visual phenomena, just as for all the naked-eye (Galactic) supernovae in recorded history. Nonetheless the event may alter our behaviour. How will we react to a bright supernova? How will this reaction differ from that to the last occurrence, a naked-eye supernova much fainter than our imagined one, which took place in 1604? While we may feel unqualified to do so, scientists surely will be asked to opine on such matters, should the rare event take place.

Our hypothetical supernova would be the sudden brightening of a star in the sky. Its light would remain concentrated in a point, with long diffraction spikes produced by the eye's cornea. Shadows cast by it would consist only of umbra; the shadow edges would be sharp. The supernova would, for a time, be visible day and night. Let us further imagine that the supernova is located on the celestial sphere (and first occurs on a day of the year) so as to maximize its visibility as a function of world population — perhaps in the plane of the Milky Way. We place our hypothetical supernova with apologies to the people of Norway, who might welcome the light from a high-declination supernova during a long, cold winter's night.

The reader may feel that much of this scenario is moot. Today, many of us live enclosed, urban lives. Our experience of the sky is muted by light pollution. Yet the brightness of the supernova is not the entire story. We argue that it is the temporary nature of an unexpected celestial event that engenders widespread, popular response, in addition to simply its brightness.

Psychologically, the majority of people still live in a pre-Copernican universe: most of us, most of the time, dislike change, whether it is the replacement of our favorite soft drink by "new, improved (high-fructose corn-syrup) Ceptsi", or even just a name replacement. Nunavut applied to part of northern Canada apparently disturbed only a few Canadians; Mumbai and Myanmar troubled writers on foreign affairs and those who thought they knew their geography. But the removal of Pluto from the canonical nine planets (done first by the Rose Planetarium in New York and then later, but more officially, by the International Astronomical Union) upset many. A good deal of the latter fuss and bother arose because the media gave the impression that something about Pluto actually had *changed*.

In particular, changes in the sky offend many of the folk who notice them. Every observatory, planetarium, and university astronomer is used to telephone calls about flying saucers when Venus reaches greatest western elongation. Yet that configuration has happened many times before in the callers' lives. Apparently duration is important. Spectacular *Iridium* (satellite) flares occur frequently, but they last for seconds at most, and hardly anybody notices them. But our hypothetical supernova will be bright at least as long as a typical bright appearance of Venus. A theorist's supernova fades with a half-life of 77 days (the half-life of cobalt 56 decaying to iron 56), giving us more than two years from a peak at $V = -12^{m}{\cdot}5$ to a Venus-like $V = -4^{m}{\cdot}5$. Changes in the sky on the order of days, weeks, or months provoke an emotional response, especially novel changes. And after more than four-hundred years, the supernova will be effectively novel.

What does history teach us to expect? Stephenson & Green[6] have compiled just about everything there is to be said about the events of 1006, 1054, 1181,

1572, and 1604. SN 1006 was the brightest of these, at perhaps $V = -7^{m}{\cdot}5$ to $V = -9^{m}{\cdot}5$ — still far below our $-12^{m}{\cdot}5$. Moreover, the world one thousand years ago was much different from the one in which we live. Still, the 1006 supernova was well documented; what do these documents tell us?

Those that have survived come from Latin, Syriac, Arab, Chinese, and Japanese sources. (The 1006 supernova occurred at low declination in the constellation Lupus and culminated in the daytime.) Those records originally were catalogued by Goldstein[7] and by Goldstein & Ho[8]. Latin reports are confused by the fact that the supernova sometimes was referred to[9] as a "comet".

'Alī ibn Ridwān (*circa* 988–1061) tells us that the supernova explains why civil wars had recently broken out among Muslims in Arabia, as well as famine and pestilence. According to this Egyptian astrologer, the supernova "claimed" thousands of victims. In Switzerland, the supernova was merely connected to a three-month drought. That it was reflected upon at all in Europe was not a given, considering that European cosmology of the time rejected the notion of celestial change altogether.

The story from China is more interesting. In 1006, Chou K'o-ming (954–1017), of the Imperial Astronomical Bureau, was travelling outside of the capital when the supernova appeared. On their own, people could not decide what kind of omen the supernova presented and were anxious. At first, it was considered a *Kuo Huang* star, which foretold war, flood, starvation, epidemic, and ill-fortune for the ruler. This was understandable because most 'guest stars' in the ancient Chinese sky were considered to be prodigies. However, upon his return, Chou K'o-ming declared the 1006 supernova a *Chou-po* star, a portent only seen during the reign of a virtuous and wise Emperor. The Emperor was, needless to say, pleased, and instructed civil and military officers throughout the country to celebrate the supernova, thereby calming the people and rating Chou K'o-ming a promotion. This is a fascinating appeal to authority as *Chou-po* were, by definition, yellow in color. The 1006 supernova most likely was bluish white. Thus, the population was asked to believe what they were told, not what their eyes showed them.

In Japan, the debate was about whether the 'guest star' was new or the brightening of an existing star. Regardless, it presaged an important event. Offerings were made, and a prominent general asked for amnesty in regard to unstated crimes.

The world of 2010 is much different from that of ten centuries ago. We now know what a supernova is, as a physical phenomenon. As opposed to before the so-called Scientific Revolution, supernovae today have (to use the modern term) scientific meaning. This does not prevent the supernova from *also* still having metaphysical meaning — usually predictive — to certain people. Might our future supernova augur favourably (as it did to Chou K'o-ming) or unfavourably (as it did to 'Alī ibn Ridwān)? Solar eclipses typically are said to foreshadow unfortunate outcomes. A supernova is a sort of 'anti-eclipse' — a noon at midnight as opposed to the darkness at noon of an eclipse. Thus, the supernova plausibly could be interpreted as a positive sign — except that it probably will not be, insofar as change in the sky is, by default, 'bad'. So, just as in 1604, our hypothetical supernova might be considered an apocalyptic omen by some. (Somebody surely will trot out Nostradamus.) Alternatively, it might be said to herald political change or punishment at hand for wrong-doers. These are all historically standard interpretations.

Extreme reactions are more likely to occur today on the metaphysical fringe, as opposed to within 'mainstream' established religions. Here, there may be a spectrum of responses. For instance, we might anticipate little outward reaction among the Buddhists, Hindus, Taoists, and Confucian adherents of the world. Our expectation is that the event would seem most important to the 'synoptic' religions — whose theology is closely coupled to events in human history. (We invite readers with greater expertise than the authors to provide us with their opinions.)

There are superficial similarities between the supernova and the Christian gospel's Star of Bethlehem; this religion just might interpret the supernova as, at least, a symbol of hope. (The arrival of a second Christ child is a less likely interpretation than is the Second Coming, though.) Moreover, if the supernova appears near the plane of the Moon's orbit, it might for several months produce a spectacular star-and-crescent every 27·3 days, an important Islamic symbol, and the learned might think of the 86th *surah* of the *Qu'ran*, 'The Night Visitant'.

Within traditional Judaism, the end of the Sabbath is signalled by the visibility of three stars. The idea is to make the Sabbath linger as long as possible, since tradition expects that the Messiah will come on that day. Planets are included along with stars for this purpose, so presumably a supernova would count. Perhaps the Sabbath will end a little earlier during the supernova apparition.

Notice that, heretofore, we have described a reaction to a supernova not that different from those expected (and experienced) during the 16th and 17th Centuries. Historical analogies may only take us so far, though. In the 21st Century, many human beings' fear of change in the sky has been altered forever by history. Today our fright is based upon the potential for terrestrial collisions, whereas in Aristotelian times the heavens and Earth were thought separate. (It used to be taken for granted that 'heavenly objects' could not physically encounter 'Earthly objects'.) The supernova, immobile on the celestial sphere, likely would not trigger the distinctly modern fear of impact. On the other hand, historian of science JoAnn Eisberg ran a test: She Googled 'supernova' and got "destruction of the Earth" and "Armageddon . . .". These were (out-of-context) excerpts from reputable sites! That a bright supernova need not be a 'kill-radius' supernova will be lost on many, and indeed such confusion might spread angst in the 'blogosphere'. Even though our particular supernova may be harmless, it will be a reminder that life on the Earth is contingent.

Another major difference between today and 1604 is technological. All past bright supernovae occurred during the pre-telescopic age. Our supernova might be discovered as brightening while still only very slightly brighter than the $V = -0{\cdot}5^{m}$ to $V = 1^{m}$ we see for Betelgeuse and Antares now. Neutrino astronomy of the 21st Century might well allow the detection of carbon-fusion onset (when the star's neutrino luminosity begins to exceed the photon luminosity) in those or other supernovae progenitors. If the supernova is not — literally — a 'new' star, is its psychological impact lessened?

The public response to our supernova will very much depend upon the rapidity with which media address the matter, and the tack they decide to take: sensationalizing imagined danger or merely presenting a *YouTube* curiosity. If it is the latter, the subject quickly will drop out of the news cycle. One of our colleagues is cynical about the corporate response: "When the month of brightness [is] over the event would be obliterated from memory by a scandal involving the Obamas' pupp[y]."

So far, we have addressed a broad, sociological response. At the strictly personal level, would there be people who, due to the supernova, pay attention to the sky for the first time in their lives? The appearance of Comet C/1995 Hale–Bopp may be used as a comparison. (We choose this comet as opposed to, say, 1P/Halley, which benefitted from inherited fame and a propaganda machine prior to its arrival.) Indeed, there undoubtedly would be public confusion as to the difference between a supernova and a comet (again), depending upon when the last bright comet had appeared in the sky and the extent of its tail. There is an important distinction, however: a supernova will not change its appearance, as comets do, during its apparition; it only will fade. Will this constancy cause human interest to diminish as well?

More prosaically, there will be few practical consequences of our supernova, beyond some possible low-amplitude flutter in the financial markets. Of course, certain individuals (astrologers?) will attempt to profit personally from the event. Furthermore, there are probably no strategic or political implications of the supernova. (In the excitement of the moment, we hope people do not mistake the supernova for the futuristic 'Star Wars' laser weapons that we have heard so much about.) However, tactical warfare — of which there are, sadly, perpetual examples worldwide — always has been affected by nocturnal illumination (*e.g.*, moonlight). A month or six weeks in which there is little 'cover of darkness' might alter fighting tactics. We suppose this applies to hunting and fishing, too. More generally, we are curious as to how many gadgets now include some sort of Sun sensor — which could be made to malfunction by an unexpected bright light. Letting our minds roam, we wonder whether *animals* will react to a supernova.

What fun it is to speculate on our supernova's effect upon the arts. Might a supernova lead to a neo-romanticism in regard to the sky? Steve Renshaw, in Japan, predicts easy entry of such a phenomenon into pop culture: he imagines new *anime* characters 'Novaboy' and 'Novagirl'! (Picture the action figures.) How will Conan O'Brien, David Letterman, and John Stewart deal with it? And we refer just to that sliver of world popular culture that is called Western.

Closer to our professional 'home turf', and more within our speculative comfort zone, a $V = -12^{m}{\cdot}5$ supernova would cause the illumination from the Milky Way to disappear and astronomers to lose their coveted dark time. Meanwhile, all of us who read *The Observatory* would 'gear up' for the increased number of visitors at public and educational observatories. (What will they see besides a blinding light? Well, at 150 pc, the light echo will be resolved after 1–2 days and the ejecta after 1–2 months.) That the supernova would lead to increased funding in science and science education is, to us, a bit of a pipe dream, albeit a pleasant one.

Will any of this happen? What unforeseeable influence will our supernova have? Our hypotheses are largely untestable. We are tempted to perform an experiment suggested to us by John Westfall: hang a shiny Christmas ornament somewhere high, such that its specular reflection of the Sun is visible. (It will have to be at just the right distance from the observer so that its 'magnitude' equals $-12^{m}{\cdot}5$.) Then watch to see if passers-by notice it *at all*.

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Yours faithfully,
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The First SETI Scans

This letter is not meant to be a search for 'sources' of the long-standing debate that led up to the first SETI scan to find artificial signals from possible technological alien civilizations. It aims rather at meriting praise to all involved in Project Ozma, the 50th anniversary of which fell on April 8 this year.

The technology used for the scan, focussed on the 21-cm hydrogen line, had been developed by Frank Drake, along with his associates John Findlay, David Heeschen, and Ross Meadows, at the National Radio Astronomy Observatory (NRAO) in Green Bank, West Virgina. The reasoning for the Project was the