b4 Is Sun constant? < neutrinos; sunspots >

Walter Baade, at Palomar during the Second World War, observed that the halo of the great spiral Andromeda galaxy was dominated by red, metal-depleted stars, whereas its disk contained mainly blue, metal-enriched stars. (Astronomers, to the exasperation of chemists, persist in using "metals" to describe all the elements heavier than helium. But the term, along with "metallicity" [Sun's Fe to H ratio is its unit], is too thoroughly entrenched to be replaced). —Stuart Ross-Taylor.[1]

One of the great intellectual achievements of the past millennium was realizing that the Sun is a star and the Earth is a planet. Over 400 years, this idea has gone from an excuse to burn the astronomer Giordano Bruno at the stake to a banality reserved for trick questions such as: "What is the nearest star to the Earth?" —Norman H. Sleep.[2]

... The IPCC [Intergovernmental Panel on Climate Change] and its authors have closed their minds and eyes to this evolving science which points to solar variability as the prime driver of earth's climate and not the human-added greenhouse gases. —Madhav L. Khandekar.[3]

The development of particle physics in the 1930s enabled **Hans Albrecht Bethe** (pronounced *bet-uh*) (1906-2005),[4] upon a suggestion by Carl-Friedrich von Weizsäcker, to lay out in 1938 how Sun continues to shine.[5] He and Charles Critchfield described how fusion of two protons into deuterium, and subsequent thermonuclear reactions, leads to helium (***Footnote b4.1***). In 1939,[6] Bethe detailed a nitrogen and carbon (as catalyst) cycle that at high confining pressure deep within Sun's interior converts 600 million tons of hydrogen nuclei ^{1}H to 595.7 million tons of helium nuclei ^{4}He per second (the 4.3 million tones loss of mass each second being radiated). This can only (!) continue for another 5-7 billion years when abruptly Sun's red giant phase sets in—its diameter is then 30-100 times greater and in its shine, Earth evaporates.[7] Sun's thermonuclear energy is mostly released as gamma rays. These photons take some 50,000 years (via electron capture and reradiation at ever longer wavelengths) to arrive mostly as green light (longer time for red and shorter for blue, and so on—and which, bundled together, we see as white) at Sun's surface (black-body green temperature of 5770 K). Some three per cent of the energy should be emitted directly as neutrinos John Norris Bahcall (1935-2005) calculated in 1964. Neutrinos can escape unscathed from Sun's deep inner regions because of their very small interaction probabilities. The successful detection of these elusive solar particles (1/3 of the flux of them by Raymond Davis Jr. beginning in 1970 at 4,850 feet down in Homestake (gold) Mine, Lead, SD)[8] began confirmation of fundamental theories about stellar interiors.[9]

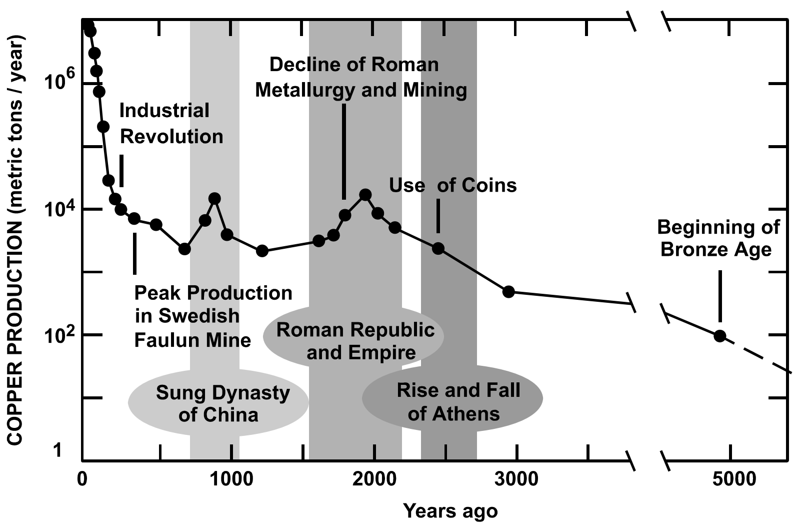

Figure b3.2 Copper-smelting production since the Bronze Age beginning in the Old World.[31] (New World oldest metalworking is of beaten native copper and gold, 3,000 years ago, Peru.)[32]

Sun's luminosity has been measured since the beginning of the 20th century with increasing precision. Sun has an eleven year (ranges from 8 - 16 years) sunspot cycle. Into this century and through the last, the number of sunspots has increased with each 11-year cycle of solar activity. By contrast, during the coldest part of the Little Ice Age, the time of the so-called *Maunder minimum* (ended 1715, began 1645), if anyone did indeed look, few or no sunspots were reported.[10]

Tree rings and ice cores record a minimum in the solar magnetic activity that coincides with the Maunder minimum. Average global temperatures, estimated from these same, were 0.2- 0.6 °C lower than today. Cosmic rays cause high level sunlight-reflective cloud haze. Sunspots add to the solar wind which deflects cosmic rays. Earth's climate cools/warms as there be less/more sunspots, Henrik Svensmark finds.[11] Also, the 70-year Maunder minimum does indicate for Sun a long-term variability.

Satellite data make "solar constant" (Sun's total brightness) a non sequitur. Sun's total brightness fluctuates 0.2 percent over a period of a few weeks and the solar output waned 0.1 percent to a minimum in 1986 from a recorded peak of the solar cycle in 1980. Nothing definite has been discovered so far bearing on this short-term variation of Sun's output and the recorded climate.[12]

Calculations that take into account the synergy of vegetation, water vapor, wind, ocean circulation, and solar dimming of 0.25 percent from Sun's usual output flux of 1367 Watts (Robert W. Noyes, 1982)[13] or 1360 Watts (Leslie F. Musk, 1988)[14] per square meter at one astronomical unit distance, can find world-climate variations as the 560-year-long Little Ice Age (ended 1860, began 1300).

Sun's *known* variability cannot explain all the warming since the Little Ice Age.

Fluctuations in the production of carbon-14 in the upper atmosphere is related to solar activity. Measurements of variations carbon-14 to ordinary carbon-12 in tree rings do not show any significant correlation with the known climatic variation or that which can be inferred from the growth rate of trees for thousands of years into the past. Also, what is currently happening at Sun's surface is not correlatable with what is happening in its deep interior. Light photons shining forth begin as a gamma rays released by nuclear fusion deep in Sun's interior tens of thousands of years earlier (*recall above*). However, the Little Ice Age separated by the Holocene warm "climatic optimum" 4500-7000 BP from a like cold time that ended 8100 years ago are part of a repeating pattern of longer-term cold snaps during the Holocene that do not correlate with recorded climate modifying events such as changes in ocean circulation. For these, Eelco J. Rohling and Heiko Pälike in 2005 posit solar output fluctuations as an explanation.[15] Spectral analysis performed on records of cosmogenic nuclides (which are commonly used as proxies for solar variability) evidence a Wolfgang Gleissberg (1903-1986) 88(70-100)-year solar cycle (during the last 12,000 years) and a Hessel de Vries (or Suess) ~205-year solar cycle during the last Ice-age. The superposition of these in the hands of Holger Braun results in a variability repeat with a 1,470-year period that is the approximate spacing of Dansgaard–Oeschger events (*see* Topic *b30*) found in Greenland ice-cores.[16]

Funding to monitor the solar constant from space has been urged by climate modeler James E. Hansen of NASA who in 1992 said: "If you could make only one measurement related to long-term climate, I would say that it should measure the thing that drives the system, and that is the sun."[17] Satellites have been tracking the solar energy bathing Earth since 1978 (ERB satellite), but the data gathering (by dedicated satellites: ACRIM I 1980-89, ACRIM II 1991-97)[18] has been discontinuous and time has been too little to separate with certainty any long-term trend component from the 0.01 percent fluctuation linked to the sunspot cycle. However, in the early 1800s, William Herschel found the correlation: more sunspots & cheaper wheat implying warmer weather & bumper crops.[19] ❑

Footnote b4.1 In 1868, the bright-yellow spectral line seen in a total solar eclipse prominence by Pierre Janssen was separately observed in Sun's chromosphere by Norman Lockyer who from its 587.49 nanometres wavelength concluded it to be due to a till-then unknown element that he, with Edward Frankland, named helium, (after Gk. *helios,* Sun) and which element (He) on Earth was physically found by William Ramsay in 1895.[20]