WORK-IN-PROGRESS (JANUARY 9, 2014) PARALLEL CHART FOR

41:4, 41:6, 41:8
("Sun Density," "Calcium—The Wanderer of Space," and "Solar-Energy Reactions")

Sources for 41:4, 41:6, 41:8

(1) A. S. Eddington, M.A., D.Sc., LL.D., F.R.S., *Stars and Atoms* (Oxford: Clarendon Press, 1927)

(2) Dr. G. Gamow, "Neutrinos vs. Supernovae," *The Scientific Monthly,* January 1942

Key

(a) Green indicates where a source author first appears, or where he/she reappears.

(b) Yellow highlights most parallelisms.

(c) Tan highlights parallelisms not occurring on the same row, or parallelisms separated by yellowed parallelisms.

(d) An underlined word or words indicates where the source and the UB writer pointedly differ from each other.

(e) Blue indicates original (or "revealed") information, or UB-specific terminology and concepts. (What to highlight in this regard is debatable; the highlights are tentative.)

Matthew Block
9 January 2014

PAPER 41 — PHYSICAL ASPECTS OF THE LOCAL UNIVERSE

4. SUN DENSITY

I: THE INTERIOR OF A STAR (Eddington 9)

Radiation Pressure and Mass (Eddington 9)

41:4.1 The mass of your sun is slightly greater than the estimate of your physicists, who have reckoned it as

The mass of the sun is—I will write it on the blackboard—2000000000000000000000000000 tons (E 24).

about two octillion (2 x 10^{27}) tons.

II: SOME RECENT INVESTIGATIONS (Eddington 42)

The Story of the Companion of Sirius (Eddington 48)

[?]

It now exists about halfway between the most dense and the most diffuse stars,

[The sun's] density of 1½ times that of water is still very far indeed from the maximum density of stellar matter; and it is therefore entirely reasonable that we should find it behaving like a perfect gas (E 52-53).

having about one and one-half times the density of water.

I: THE INTERIOR OF A STAR (Eddington 9)

Dense Stars (Eddington 36)

But your sun is neither a liquid nor a solid—

The sun's material, in spite of being denser than water, really is a perfect gas.

it is gaseous—

It sounds incredible, but it must be so (E 38).

and this is true notwithstanding the difficulty of explaining how gaseous matter can attain this and even much greater densities.

[*Compare:* The feature of a true gas is that there is plenty of room between the separate particles—a gas contains very little substance and lots of emptiness. Consequently when you squeeze it you do not have to squeeze the substance; you just squeeze out some of the waste space (E 38).]

41:4.2 Gaseous, liquid, and solid states are matters of atomic-molecular relationships, but density is a relationship of space and mass. Density varies directly with the quantity of mass in space and inversely with the amount of space in mass, the space between the central cores of matter and the particles which whirl around these centers as well as the space within such material particles.

41:4.3 Cooling stars can be physically gaseous and tremendously dense at the same time.

You are not familiar with

Careful investigation has shown that in the small stars on the extreme left of Fig. 7 the electric charges of the atoms and electrons bring about a slight deviation from the ordinary laws of a gas; it has been shown by R. H. Fowler that the effect is to make the gas not imperfect but *superperfect*—it is *more* easily compressed than an ordinary gas (E 40).

the solar *supergases*,

but these and other unusual forms of matter explain how even nonsolid suns can attain

SOURCE OR PARALLEL	URANTIA PAPER 41
Is it impossible that a perfect gas should have the density of iron? The answer is rather surprising. There is no earthly reason why a perfect gas should not have a density far exceeding iron (E 38).	a density equal to iron—
[Compare 58:5.5.]	about the same as Urantia—
	and yet be in a highly heated gaseous state and continue to function as suns.
The big terrestrial atoms which begin to jam at a density near that of the liquid state do not exist in the stars. The stellar atoms have been trimmed down by the breaking off of all their outer electrons. The lighter atoms are stripped to the bare nucleus—of quite insignificant size.	The atoms in these dense supergases are exceptionally small;
The heavier atoms retain a few of the closer electrons, but have not much more than a hundredth of the diameter of a fully arrayed atom (E 39).	they contain few electrons.
	Such suns have also largely lost their free ultimatonic stores of energy.
II: SOME RECENT INVESTIGATIONS (Eddington 42)	
The Story of the Companion of Sirius (Eddington 48)	
	41:4.4 One of your near-by suns, which started life with about the same mass as yours, has now contracted
Working out the sum more accurately we find that the Companion of Sirius is a globe intermediate in size between the earth and the next larger planet Uranus (E 50).	almost to the size of Urantia,
The actual density works out at 60,000 times that of water—	having become sixty thousand times as dense as your sun. [*Note:* Changed to 'forty thousand times' in second edition.]

SOURCE OR PARALLEL	URANTIA PAPER 41
	The weight of this hot-cold gaseous-solid
just about a ton to the cubic inch (E 50).	is about one ton per cubic inch.
[*Note:* The Companion of Sirius is a white dwarf.]	And still this sun shines with a faint reddish glow, the senile glimmer of a dying monarch of light.
	41:4.5 Most of the suns, however, are not so dense.
I: THE INTERIOR OF A STAR (Eddington 9)	
Opacity of Stellar Matter (Eddington 28)	
The mean density of Capella is nearly the same as the density of the air (E 29, footnote).	One of your nearer neighbors has a density exactly equal to that of your atmosphere at sea level.
The Relation of Brightness to Mass (Eddington 31)	
In many stars the material is so inflated that it is more tenuous than the air around us; for example, if you were inside Capella you would not notice the material of Capella any more than you notice the air in this room (E 31).	If you were in the interior of this sun, you would be unable to discern anything.
	And temperature permitting, you could penetrate the majority of the suns which twinkle in the night sky and notice no more matter than you perceive in the air of your earthly living rooms.
II: SOME RECENT INVESTIGATIONS (Eddington 42)	
The Cloud in Space (Eddington 63)	
Some of the stars of extremely rarefied. Betelgeuse, for example,	41:4.6 The massive sun of Veluntia,
	one of the largest in Orvonton,
has a density about a thousandth that of air.	has a density only one one-thousandth that of Urantia's atmosphere.

SOURCE OR PARALLEL	URANTIA PAPER 41
	Were it in composition similar to your atmosphere and not superheated,
We should call it a vacuum	it would be such a vacuum that human beings would speedily suffocate if they were in or on it.
were it not contrasted with the much greater vacuosity of surrounding space (E 64).	
The Story of Betelgeuse (Eddington 76)	
By spectroscopic analysis we know that Betelgeuse	41:4.7 Another of the Orvonton giants
has a surface temperature about 3,000º (E 78).	now has a surface temperature a trifle under three thousand degrees.
The diameter is about 300 million miles.	Its diameter is over three hundred million miles—
Betelgeuse is large enough to contain the whole orbit of the earth inside it, perhaps even the orbit of Mars.	ample room to accommodate your sun and the present orbit of the earth.
Its volume is about fifty million times the volume of the sun (E 82).	And yet, for all this enormous size, over forty million times that of your sun,
[contd] There is no direct way of learning the mass of Betelgeuse because it has no companion near it whose motion it might influence. We can, however, deduce a mass from the mass-brightness relation in Fig. 7. This gives the mass equal to 35 x sun (E 82).	its mass is only about thirty times greater.
The Cloud in Space (Eddington 63)	
A nebula has no definite boundary and the density gradually fades off.... Before we pass entirely out of the sphere of one nebula we enter the sphere of another, so that there is always some residual density in interstellar space (E 64).	These enormous suns have an extending fringe that reaches almost from one to the other.

6. CALCIUM—THE WANDERER OF SPACE

II: SOME RECENT INVESTIGATIONS (Eddington 42)

Unknown Atoms and Interpretation of Spectra (Eddington 53)

[Compare E 53-57.]

41:6.1 In deciphering spectral phenomena, it should be remembered that space is not empty; that light, in traversing space, is sometimes slightly modified by the various forms of energy and matter which circulate in all organized space. Some of the lines indicating unknown matter which appear in the spectra of your sun are due to modifications of well-known elements which are floating throughout space in shattered form, the atomic casualties of the fierce encounters of the solar elemental battles.

The Cloud in Space (Eddington 63)

There seems to be no doubt that the medium containing the sodium and ionized calcium—and no doubt many other elements which do not show themselves—is separate from the earth and the star. It is the 'fullness' of interstellar space already mentioned (E 66).

Space is pervaded by these wandering derelicts, especially sodium and calcium.

[!]

41:6.2 Calcium is, in fact, the chief element of the matter-permeation of space throughout Orvonton. Our whole super-universe is sprinkled with minutely pulverized stone. Stone is literally the basic building matter for the planets and spheres of space.

Plaskett ... showed that whereas the stars themselves had all sorts of individual velocities, the material of the fixed [calcium and sodium] lines had the same or nearly the same velocity in all parts of the sky, as though it were one continuous medium throughout interstellar space. I think there can be no doubt that this research demonstrates the existence of a cosmic cloud pervading the stellar system (E 67).

The cosmic cloud, the great space blanket, consists for the most part of the modified atoms of calcium.

Unknown Atoms and Interpretation of Spectra (Eddington 53)

The stone atom is one of the most prevalent and persistent of the elements.

Surveying the series of stars from the coolest to the hottest, we can trace how the calcium atoms are at first whole, then singly ionized, then doubly ionized—a sign that the battering becomes the more severe as the heat becomes more intense (E 57).

It not only endures solar ionization—splitting—

but persists in an associative identity even after it has been battered by the destructive X rays and shattered by the high solar temperatures.

Calcium possesses an individuality and a longevity excelling all of the more common forms of matter.

SOURCE OR PARALLEL	URANTIA PAPER 41
The Sun's Chromosphere (Eddington 70)	
	41:6.3 As your physicists have suspected, these mutilated remnants of solar calcium literally ride the light beams for varied distances, and thus their widespread dissemination throughout space is tremendously facilitated. The sodium atom, under certain modifications, is also capable of light and energy locomotion. The calcium feat is all the more remarkable since this element has almost twice the mass of sodium. Local space-permeation by calcium is due to the fact that it escapes from the solar photosphere, in modified form, by
The ordinary atmosphere of the sun terminates rather abruptly, but above it there is a deep though very rarefied layer called the chromosphere consisting of a few selected elements which are able to float—float, not on the top of the sun's atmosphere, but on the *sunbeams*. The art of riding a sunbeam is evidently rather difficult, because only a few of the elements have the necessary skill.	literally riding the outgoing sunbeams.
The most expert is calcium (E 70).	Of all the solar elements, calcium, notwithstanding its comparative bulk—containing as it does twenty revolving electrons—is the most successful
≠	in escaping from the solar interior to the realms of space.
	This explains why there is
The layer of calcium suspended on the sunlight is at least 5,000 miles thick (E 70).	a calcium layer, a gaseous stone surface, on the sun six thousand miles thick;
[It has always seemed odd that a rather heavy element (No. 20 in order of atomic weight) should be found in these uppermost regions where one would expect only the lightest atoms (E 72).]	and this despite the fact that nineteen lighter elements, and numerous heavier ones, are underneath.

41:6.4 Calcium is an active and versatile element at solar temperatures.

The ordinary calcium atom has two rather loose electrons in its attendant system; the chemists express this by saying that it is a divalent element, the two loose electrons being especially important in determining the chemical behaviour (E 71).

The stone atom has two agile and loosely attached electrons in the two outer electronic circuits,

which are very close together.

But under the conditions prevailing in the chromosphere one of the electrons is broken away, and the calcium atoms are in the same smashed state that gives rise to the 'fixed lines' in the interstellar cloud (E 71).

Early in the atomic struggle it loses its outer electron;

Calcium scores because it possesses a possible orbit of excitation only a little way above the normal orbit so that it can juggle the electron between these two orbits without serious risk (E 73).

whereupon it engages in a masterful act of juggling the nineteenth electron back and forth between the nineteenth and twentieth circuits of electronic revolution.

We now see that the special skill demanded is to be able to toss up an electron 20,000 times a second without ever making the fatal blunder of dropping it (E 72).

By tossing this nineteenth electron back and forth between its own orbit and that of its lost companion more than twenty-five thousand times a second,

a mutilated stone atom is able partially to defy gravity and thus successfully to ride the emerging streams of light and energy, the sunbeams, to liberty and adventure.

The atoms in the chromosphere are kept floating above the sun like tiny shuttlecocks, dropping a little and then ascending again from the impulse of the light (E 71).

This calcium atom moves outward by alternate jerks of forward propulsion, grasping and letting go the sunbeam

about twenty-five thousand times each second.

SOURCE OR PARALLEL	URANTIA PAPER 41
	And this is why stone is the chief component of the worlds of space. Calcium is the most expert solar-prison escaper.
	41:6.5 The agility of this acrobatic calcium electron is indicated by the fact that,
Milne's result is that an electron tossed into the higher solar orbit	when tossed by the temperature-X-ray solar forces to the circle of the higher orbit,
remains there for an average time of a hundred-millionth of a second before it spontaneously drops back again.	it only remains in that orbit for about one one-millionth of a second;
I may add that during this brief time it makes something like a million revolutions in the upper orbit (E 73-74).	but before the electric-gravity power of the atomic nucleus pulls it back into its old orbit, it is able to complete one million revolutions about the atomic center.
[Contrast E 75-76, re Eddington's speculation that calcium would escape into outer space in connection with the explosion of 'new stars' or novae.]	41:6.6 Your sun has parted with an enormous quantity of its calcium, having lost tremendous amounts during the times of its convulsive eruptions in connection with the formation of the solar system.
By Milne's theory we can calculate the whole weight of the sun's calcium chromosphere. Its mass is about 300 million tons. One scarcely expects to meet with such a trifling figure in astronomy (E 76).	Much of the solar calcium is now in the outer crust of the sun.
Unknown Atoms and Interpretation of Spectra (Eddington 53)	
	41:6.7 It should be remembered that spectral analyses show only sun-surface compositions.

SOURCE OR PARALLEL	URANTIA PAPER 41
In the spectrum of Sirius the lines of hydrogen are exceedingly prominent and overwhelm everything else. We do not infer that Sirius is composed mainly of hydrogen; we infer instead that its surface is at a temperature near 10,000º, because it can be calculated that that is a temperature most favourable for a great development of these hydrogen lines. In the sun the most prominent spectrum is iron.	For example: Solar spectra exhibit many iron lines,
We do not infer that the sun is unusually rich in iron;	but iron is not the chief element in the sun.
	This phenomenon is almost wholly due to the present temperature of the sun's surface,
we infer that it is at a comparatively low temperature near 6000º favourable for the production of the iron spectrum (E 58).	a little less than 6,000 degrees, this temperature being very favorable to the registry of the iron spectrum.

8. SOLAR-ENERGY REACTIONS

"NEUTRINOS VS. SUPERNOVAE" (Gamow 65)

STELLAR EVOLUTION (Gamow 65)

41:8.1 In those suns which are encircuited in the space-energy channels,

But, although it was already clear at that time [1929] that the thermonuclear reaction responsible for the energy supply of stars must be taking place between hydrogen nuclei (protons) and the nuclei of some other light element, the insufficient knowledge of various nuclear processes prevented the discovery of the reaction itself. And it was only recently (1939) that the particular nuclear reaction, or rather chain of reactions, responsible for the energy production in the sun and all other stars of the main sequence was found by Bethe.

solar energy is liberated by various complex nuclear-reaction chains,

the most common of which is the hydrogen-carbon-helium reaction.

[See seven rows down.]

In this metamorphosis, carbon acts as an energy catalyst since it is in no way actually changed by this process of converting hydrogen into helium.

According to Bethe, the light element which reacts with hydrogen (in the nuclear sense) at the high temperatures of the stellar interior is ordinary carbon. Penetrating into the interior of carbon nuclei, protons emit their surplus energy in the form of hard γ-rays, and remain in the bound state, thus giving rise to somewhat heavier nuclei.

Under certain conditions of high temperature the hydrogen penetrates the carbon nuclei.

However, the nucleus of carbon can not hold more than four protons

Since the carbon cannot hold more than four such protons,

SOURCE OR PARALLEL	URANTIA PAPER 41
and, as soon as the saturation point is reached,	when this saturation state is attained,
	it begins to emit protons as fast as new ones arrive.
	In this reaction the ingoing hydrogen particles come forth as
it "spits them out" in the form of a single α-particle, or the nucleus of a helium atom.	a helium atom.
The carbon nucleus emerging from this process in its original form is ready again to capture new protons and to unite them into a new α-particle. Thus we see that the carbon plays only the role of what the chemists would call a catalizer, and the net result of nuclear reaction is the transformation of hydrogen into helium (G 66).	
Since the nuclear reactions, transforming hydrogen into helium, cause definite changes in the physical properties of stellar matter, one should expect that they must result in certain changes of the observed characteristics of the star itself. This question was studied in some detail by the author of this article, and it was found that the steady decrease of the hydrogen content in the star must lead to a quite considerable increase of its luminosity (G 66).	41:8.2 Reduction of hydrogen content increases the luminosity of a sun.
	In the suns destined to burn out,
After the star, following the path of its evolution, reaches this state of maximum luminosity, the hydrogen content in its body will be entirely exhausted (G 66).	the height of luminosity is attained at the point of hydrogen exhaustion.
During these late stages of stellar evolution,	Subsequent to this point,

SOURCE OR PARALLEL	URANTIA PAPER 41
the radiation of the star is supported by the gravitational energy liberated in contraction, and the luminosity of the aging star is gradually dropping down.	brilliance is maintained by the resultant process of gravity contraction.
The final stage of the contraction must be represented by a very dense star, which might be, however, still quite hot. Examples of such dying stars are given by the so-called "white dwarfs" possessing very low luminosities,	Eventually, such a star will become a so-called white dwarf,
and the estimated density exceeding the density of water by a factor of several hundred thousand (G 66-67).	a highly condensed sphere.
THE CAUSE OF SUDDEN COLLAPSE (Gamow 68)	
[Contrast G 68-70.]	41:8.3 In large suns—small circular nebulae—when hydrogen is exhausted and gravity contraction ensues, if such a body is not sufficiently opaque to retain the internal pressure of support for the outer gas regions, then a sudden collapse occurs.
	The gravity-electric changes give origin to vast quantities of
It was recently proposed by the author of this article and his colleague, Dr. Sch[o]enberg, that the real cause of stellar collapses is due to certain tiny particles, which were but recently introduced in physics and are known under the name of neutrinos (G 69).	tiny particles
It was first suggested by Pauli that these run-away particles, which he called "neutrinos," can account for all observed discrepancies if one supposes that they carry no electric charge and possess a mass considerably smaller than the mass of the electron (G 69).	devoid of electric potential,

It is clear from the above description of the new particle that it is just the right agent to remove the surplus energy from the interior of a contracting star, since the entire body of the star is just as transparent for neutrinos as a window pane is for ordinary light (G 69).

and such particles readily escape from the solar interior,

[Compare G 68.]

thus bringing about the collapse of a gigantic sun within a few days.

STELLAR CATASTROPHES (Gamow 67)

It was such an emigration of these "runaway particles" that occasioned

The first extragalactic supernova was observed in 1885 in the neighboring stellar system known as The Great Andromeda Nebula, its luminosity exceeding by a factor of one thousand the luminosities of all other novae ever seen in this system (G 67).

the collapse of the giant nova of the Andromeda nebula about fifty years ago.

[In the case of oxygen (where the unstable product is radioactive nitrogen with the decay period of 9 seconds) the star can lose even as much as 10^{17} ergs per second per each gram of its material. The energy losses in this ... case are so high that the complete collapse of the star takes place in only twenty-five minutes (G 70).]

This vast stellar body collapsed in forty minutes of Urantia time.

As in the case of ordinary novae, a supernova explosion gives rise to a rapidly expanding gas shell, which, however, takes a considerably larger fraction of the stellar mass. In fact, whereas the gas shells emitted by novae become thinner and thinner and dissolve themselves rapidly in the surrounding space, the gas masses emitted by supernovae form extensive luminous nebulae involving the place of explosion.

41:8.4 As a rule, the vast extrusion of matter continues to exist about the residual cooling sun as extensive clouds of nebular gases.

SOURCE OR PARALLEL	URANTIA PAPER 41
	And all this explains the origin of many types of irregular nebulae,
It can be, for example, considered as definitely established that the so-called "Crab Nebula," seen at the place of the supernova of the year 1054, was formed by gases expelled during that explosion.	such as the Crab nebula, which had its origin about nine hundred years ago,
In fact, in the very center of the Crab Nebula, observations show the presence of a faint star which, according to its observed properties, must be classified as a very dense white dwarf (G 68).	and which still exhibits the mother sphere as a lone star near the center of this irregular nebular mass.