"ASTROPHYSICS"-New Horizons: of a Generational Making the Most Opportunity

Tejas Jadhav, Yash Patil, Vyankatesh Pingale, Krushna Patil, Yash Patil, Payal Walunj

[1] *Student, Computer science, SOET, Sandip University, Maharashtra, India*
[2] *Student, Computer science, SOET, Sandip University, Maharashtra, India*
[3] *Student, Computer science, SOET, Sandip University, Maharashtra, India*
[4] *Student, Computer science, SOET, Sandip University, Maharashtra, India*
[5] *Student, Computer science, SOET, Sandip University, Maharashtra, India*
[6] *Teacher, Computer science, SOET, Sandip University, Maharashtra, India*

ABSTRACT

What is a star? What makes the stars shine? How hot are they? Do other stars besides our sun have families of planets? What exists between stars? Astrophysicists are vitally concerned with the answers to these and other problems. Before we can answer these questions, we should learn a little of the astrophysicists' language. When ordinary light is passed through an instrument known as a spectrograph it is broken up into a "rainbow" of colours called a spectrum. These colours appear in the familiar order violet, green, orange, red. In addition, radiation beyond the sensitivity of the human eye such as infrared, ultraviolet, gamma rays (from nuclear processes), and radio waves are also included in the spectrum. Each chemical element has a spectrum which is characteristic of that element alone.

Keyword: - *Astrophysics, Astronomer, Nebula, Physics, Galaxy, Neutron.*

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1. Introduction

So, what make the stars to shine?" None of the processes with which we were familiar were sufficient to keep the sun shining for the time since the birth of the earth. The key to the problem was supplied by Einstein and his magic formula $E = Mc^2$. An atom of hydrogen weighs 1.0080 units while a helium atom weighs 4.003. Thus, if an atom of helium is made from four hydrogen atoms, we will have 4 x 1.008 = 4.032 -4.003 or 0.029 atomic mass units left over. This surplus mass is converted into energy; hydrogen is the nuclear "fuel" which stars "burn" and helium the "ash." Astrophysicists believe that the sun was formed from a vast cloud of gas and dust which contracted and became hotter until the centre became our sun. While the cloud was still contracting. secondary condensations appeared. These eventually formed our planets. All stars probably were born similarly. Thus, it is very likely that many other stars also possess planetary families Out of this large number of planets, it quite possible that some are earth- type worlds.

the Great Planetary Nebula , NGC (New General Catalogue of nebulae and star clusters

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All the vast reaches of matter in the universe, of which the sun and planets are a small part, are constructed out of two fundamental particles, the nucleon and the electron. The nucleon occurs in two forms: as a neutron, which is electrically neutral; and as a proton, which carries a positive charge of electricity. These particles are extremely small, only 10-13 inches in diameter, which is one million times smaller than the smallest object that can be seen with the best electron microscope. The nucleon is relatively massive, being 1,840 times heavier than the electron. The respective masses are 1.6 X 10-24 grams and 9 X 10 28 grams. Neutrons and protons are bound together very tightly into a small compact mass called the nucleus. Together the electrons and the nucleus form the atom. Atoms are bound into solid matter by electrical forces. The earth is a large collection of such atoms cemented together. It and the other planets are all bound to the sun by the force of gravity. The sun itself is only one of 100 billion stars, which are bound together by gravitational forces into a disk-shaped mass called the galaxy. The galaxy spins on its axis once every 200 million years. Because of its spin the galaxy is flattened at its edges into the shape of a disk whose thickness is roughly only one- tenth of its diameter. We see the edge of this disk when- ever we look up into the sky at the Milky Way. The stars within the galaxy are separated from one another by a distance of 20 trillion miles, or four light years.

The force of gravity always attracts because, so to speak, there is only one kind of gravitational charge. In the three centuries of quantitative study of gravity since New-ton's time, we have never found any indication that there is a second kind of gravitational charge in the universe which might produce negative gravity or gravitational repulsion. That is why physicists react with pain to suggestions for the construction of antigravity machines. As in the case of gravity, the electrical force is inversely proportional to the square of the distance, i.e. $a * 1 / (R ^ 2)$. The strongest force in nature is the nuclear force. If we calculate the nuclear force between a neutron and a proton which are tied together in the deuteron with a binding energy of 20 million electron volts (mev), and separated by a distance $f * 2 * 10 ^ - 13 * cm$ we find (noting that 20mev=20 X 1.6 X 10 ergs):

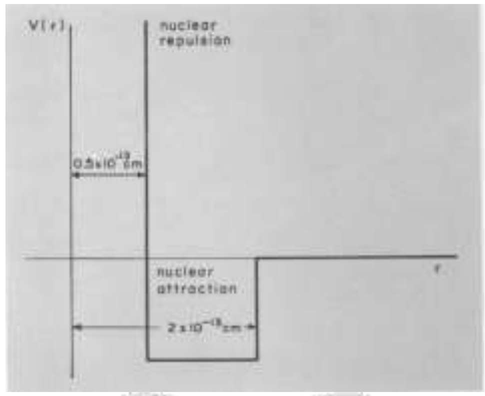

Fig.- Potential energy (V) of two neutrons, or a neutron and a proton, as a function of the distance of separation (r).

$$\text{Force} \approx \text{Energy} \div \text{distance} = 20 \times 1.6 \times 10^{-6} \text{ ergs} \div 2 \times 10^{-13} \text{ cm} \cong 10^{8} \text{ dynes.}$$

The gravitational force between these same two particles is

$$\frac{M^2G}{R^2} = \frac{(1.6 \times 10^{-24}\text{g})^2 \times (6.7 \times 10^{-8})}{(2 \times 10^{-13}\text{ cm})^2} \approx 10^{-30} \text{ dynes,}$$

However, although the strength of the nuclear force is very great, its range of action is very limited. The nuclear force between two nucleons is ineffective when their distance of separation exceeds one ten-trillionth (10-13) of an inch, whereas gravity is effective over the distance of nearly 100 million miles which separates the earth from the sun, or even over the much greater distances between stars. The nuclear force, therefore, dominates in all close encounters between protons and neutrons, but gravity dominates in the distant encounters between celestial bodies.

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$$\frac{1}{2}m\bar{v}^2 = \frac{3}{2}kT,$$

hence,

$$\bar{v} = \sqrt{\frac{3\,kT}{m}}.$$

The velocity of escape is

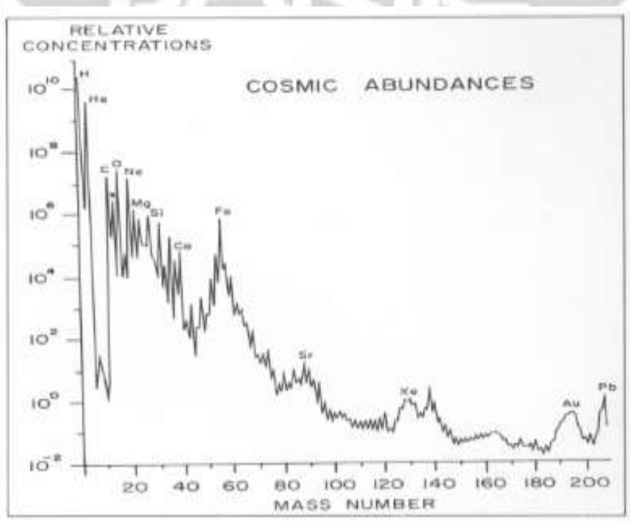
$$v_e = \sqrt{\frac{2\,MG}{R}}.$$

The preceding account of stellar evolution gives us an indication of what may be expected for the relative abundances of the elements in the universe. Hydrogen is, of course, the most abundant, helium the next, and then C, N, O, Ne, Mg, Si, S, Al, Ca, Fe, and other elements, decreasing roughly in order of atomic weight, with variations according to the values of the cross sections for the nuclear reactions which determine their rates of synthesis and their equilibrium concentrations. We expect a peak at iron, because of its high nuclear stability; and we expect low concentrations of the elements heavier than iron, which are produced entirely in the final flash of the supernova explosions, and only occur in existing stars by virtue of being drawn together, as a part of previously "used" matter, for the formation of a new star. We also expect variations in the composition of individual stars with respect to these heavier-than-iron elements, according to the number of supernovae which have exploded in their vicinity. A list of the most important elements, representing the solar composition, is given in Table 1. These abundances were selected by A. G. W. Cameron, based mostly upon observations of emission lines in the sun's chromosphere and in type-B stars (very hot stars with surface temperatures of 20,000°K), and also on the measurements of chondrites, a common species of stone meteorite often considered as representative of the average composition of planetary matter in the solar system. The abundance numbers are scaled to make the abundance of Si exactly 10º, a standard practice among those who study meteorites. Beyond Ni, the abundances become extremely small. A somewhat more complete display of the abundance as a function of the atomic number. The observed chemical abundances are commensurate with the ideas outlined above and reflect the stability of the respective nuclear species, as one expects for equilibrium concentrations produced by nucleosynthesis. The C. N, O group is found to be strong; the Mg, Al, Si group is also strong; and Fe is relatively very high. The heavier- than-iron elements fall off rapidly by three or more orders of magnitude with abundances running about 1 or 0.1, as expected from our discussion of stellar evolution.

These abundances give us an indication of the composition to be expected in the contracting cloud that formed the primitive sun. We expect H_2O, perhaps NH3, and CH, oxides of Mg, Al, Si, Ca, and Fe, all loosely joined in complex and irregular chains to make macromolecules and dust particles. Such particles are believed to exist in the interstellar medium; the polarization of starlight indicates elongated dust particles such as those which provided the original material of the planets. We are already prepared, on this basis, to understand why the composition of the earth is dominated by silicon oxides, plus oxides and carbonates of Mg, Al, and Ca. We also expect HO and N_2 as subcrustal and atmospheric constituents. We must still understand the reasons for the relative scarcity of hydrogen in the earth and its atmosphere, in comparison to its overwhelming abundance in the original materials. The treatment of this question will occupy us after the following discussion of the origin of the solar system.

Z*	Element	Abundance	Mass Fraction	Source
1	H	3.2×10^{10}	0.602	sun, relative to Si
2	He	5.0×10^{9}	0.376	B stars, relative to H
6	C	1.66×10^{7}	0.00374	sun
7	N	3.0×10^{6}	0.00079	sun
8	O	2.9×10^{7}	0.00672	sun
10	Ne	1.7×10^{7}	0.0064	B stars
11	Na	4.4×10^{4}	0.000019	chondrites, relative to Si
12	Mg	9.1×10^{5}	0.00042	chondrites
13	Al	9.5×10^{4}	0.000049	chondrites
14	Si	1.0×10^{6}	0.00053	chondrites
15	P	1.0×10^{4}	0.0000058	chondrites
16	S	3.8×10^{5}	0.00023	chondrites
17	Cl	3×10^{3}	0.000002	earth, relative to Br
18	Ar	1.5×10^{5}	0.000103	interpolated
19	K	3.3×10^{3}	0.0000024	chondrites
20	Ca	4.9×10^{4}	0.000037	chondrites
22	Ti	2.1×10^{3}	0.0000019	chondrites
24	Cr	6.4×10^{3}	0.0000063	chondrites
25	Mn	7.2×10^{3}	0.0000074	chondrites
26	Fe	1.2×10^{5}	0.000122	sun
27	Co	1.2×10^{3}	0.0000013	chondrites
28	Ni	2.5×10^{4}	0.000028	chondrites

* Atomic number of a nucleus



logarithm of the abundance is plotted as a function of Z, the atomic number, i.e., the number of nucleons in the nucleus. The abundance N is normalized with respect to silicon as 10^6.

Stage of Astrophysics:

The Three-Stage Development of Astrophysics The stages described below are designed to be suggestive rather than definitive. The temporal breaks should not be read as firm as there were very significant periods of overlap. Indeed, there are strong echoes of the 'Great Correlation Era' in evidence today, as DeVorkin has argued. There were very major shifts in each of these stages regarding conceptual tools and technologies. For the first two stages, there were also crucial institutional changes-

1) First Stage Astrophysics; C. 1860-1890. Often pursued by non-professional astronomers with limited formal training, who put the emphasis on the identification and charting of spectral lines. Essentially opportunistic, astrophysicists observed what could be observed, although often with the (usually) distant hope of being able to understand the course of stellar evolution. In this period, some, perhaps many, professional positional astronomers were sceptical about, if not hostile towards, astrophysics. Founding of the first observatories devoted to astrophysics. An exemplar of a practitioner of First Stage Astrophysics: William Huggins.
2) Second Stage Astrophysics; c. 1890-1920. Characterized by a growing number of practitioners and increased professionalization. The researchers' emphasis was on large surveys, collecting spectra and radial velocities of stars, with more emphasis on tackling specific problems rather than merely collecting data. Various attempts were made to correlate different bodies of evidence, with the most significant example being the development of what would be called the Hertzsprung-Russell Diagram. This period also witnessed the formation of the International Union for Cooperation in Solar Research in 1905 (its charge was expanded to include stellar research in 1910), and the establishment of The Astrophysical Journal in 1895. In 1921, W. Carl Rufus offered a detailed periodization of American astronomy, and he identified a 'Correlation Period that began in 1890. DeVorkin has instead termed this era 'The Great Correlation Era." Exemplars of practitioners of Second Stage Astrophysics: Ejnar Hertszprung and J.C. Kapteyn.
3) Third Stage Astrophysics; c. 1920-1950. In this phase, the field was fully professionalized. The great majority of astronomical observatories were now devoted mostly, if not entirely, to astrophysics. This era saw the introduction into astrophysical practice of state-of-the-art physical theory in terms of the new atomic physics and quantum mechanics, as well as the close combination of theory and observation with a new emphasis on the interpretation of spectral lines. Exemplars of practitioners of Third Stage Astrophysics: Pannekoek and H.N. Russell.

(Rufus 1921; DeVorkin 2010, 140.)

Other Dutch and Netherlands-based astronomers beside Pannekoek in time also swung behind Shapley's scheme. In May 1922, Shapley met in Leiden with Ejnar Hertzsprung, Pannekoek, and two of Kapteyn's students, including WJ.A. Schouten, who in 1919 had argued that Shaply had overestimated the distances to the globular clusters by a factor of around eight. Shapley, they all decided, was basically correct. 63 Pieter J. van Rhijn, who was a PhD student of Kapteyn's as well as a collaborator of his and his successor at Groningen, however, stuck to his guns. He co-authored 'On the distribution of the stars in space especially at high galactic latitudes' with Kapteyn in 1920, in which they advocated an ellipsoid model for the galactic system. The two of them also argued in 1922 that Shapley had misused the Cepheid variable stars as his main distance indicators and that his distances to them were in fact seven times too big. 64 If that were so, then Shapley's Big Galaxy would have to be shrunk.

In 1922, Kapteyn in some respects pulled together the results of his life's work on the sidereal problem in a paper published in Astrophysical Journal. He again argued for an ellipsoid model and concluded that the Sun is close to the centre of the Galaxy, and that the galactic system extends for about 8500 parses along the galactic plane and at 1700 parsecs at right angles to the plane before the star density reaches one hundredth of the density in the neighbourhood of the Sun. Even here, after decades of effort to solve the Sidereal Problem Kapteyn still wrote of a 'First attempt at a theory of the arrangement and motion of the sidereal system. In 1924, Pannekoek returned to the problem of the distribution of stars within the Galaxy to search for star clusters that, when their light was aggregated. could explain the appearance of the Milky Way. For Pannekoek, the galactic system was to be understood as an accumulation of loose clusters, and so was in line with Shapley's picture, but very different from Kapteyn's ellipsoid.

(The place of imagination and speculative reasoning in nineteenth-century science has been examined by, among others, Willis 2011.With Shapley's 'Big Galaxy' we see imaginationand speculative reasoning in early twentieth-century astronomy. Paul 1981; and van der Kruit 2015. 503. On Schouten's agig study, see also Smith 1982, Kapleyn and Rhijn 1922. Kapteyn 1922. Pannekoek 1924. For a commentary on this paper, see Tai and van Dongen 2016 and Tai 2017, 242-245

4. CONCLUSIONS

Kapteyn died in 1922. By this time, we have seen that a new sort of astro-physics had started to emerge, one that had been given its initial impetus by the researches of Meghnad Saha. We termed this ‘Third Stage Astrophysics’.Pannekoek effectively solved the problem of how to be relevant and perform ‘competitive’ research at the University of Amsterdam despite his lack of resources, including the complete lack of telescopes and an observatory, and in the face of the rise of American astronomy, by rapidly grasping the importance of Saha’s path-breaking researches and both developing and applying to actual stars this novel sort of astrophysics. Pannekoek’s initial expertise had been in positional astronomy, but he became one of the earliest practitioners of ‘Third Stage Astrophysics’.

Pannekoek also positioned himself as a modern astronomer by quickly realizing the importance of Shapley’s new picture of the stellar system, advanced publicly in 1918. The next year, Pannekoek became one of the first astronomers to publish additional evidence in support of Shapley, and ins doing underlined the severe limitations of the models developed by the statistical astronomers, including Kapteyn. Pannekoek the astronomer, then, was both very much of, as well as a maker of, his time.

5. REFERENCES

1. De ontdekkers van de hemel, De Nederlandse sterrenkunde in de twintigste eeuw,
2. Amsterdam: Prometheus Bert Bakker. Becker, Barbara J. 2011,
3. Unravelling Starlight: William and Margaret Huggins and the Rise of the New Astronomy
4. Cambridge: Cambridge University Press. Clerke, Agnes Mary. 1885.
5. A Popular History of Astronomy during the Nineteenth Century.
6. Edinburgh: Adam & Charles Black. DeVorkin, David H. 1998.
7. "The American Astronomical Community'. Review of American Astronomy: Community, Careers, and Power, 1859-1940, by John Lankford.
8. Journal for the History of Astronomy 29(4): 389-392.2000.
9. Henry Norris Russell: Dean of American Astronomers. Princeton, NJ: Princeton University Press.- 2010.
10. 'Extraordinary Claims Require Extraordinary Evidence: C.H. Payne H.N.Russell and Standards of Evidence in Early Quantitative Spectroscopy'.
11. Journal of Astronomical History and Heritage 13(2): 139-144. Baneke, David. 2005.
12. "Als bij toverslag". De renovatie en nieuwe bloei van de Leidse Sterrewacht 1918-1924'.
13. BMGN-Low Countries Historical Review 120(2): 207-225. -. 2010.
14. "Teach and Travel: Leiden Observatory and the Renaissance of Dutch Astronomy in the Interwar Years'.
15. Journal for the History of Astronomy 41(2): 167-198. Herrmann, Dieter B. 1975.
16. "Zur Vorgeschichte des Astrophy sikalischen Observa- torium Potsdam (1865 bis 1874)
17. Astronomische Nachrichten 296(6): 245-259. Holmberg, Gustav. 1999.
18. Reaching for the Stars: Studies in the History of Swedish Stellar and Nebular Astronomy, 1860-1940.
19. Lund: Lund University. Hoskin, Michael. 1976.
20. "The "Great Debate": What Really Happened.
21. Journal for the History of Astronomy 7(3): 169-182. Hufbauer, Karl. 1993.
22. Exploring the Sun: Solar Science since Galileo.
23. Baltimore: Johns Hopkins University Press. Kapteyn, Jacobus C. 1922.
24. 'First Attempt at a Theory of the Arrangement and Motion of the Sidereal System'.
25. Astrophysical Journal 55(4): 302-328. Kapteyn, Jacobus C., and Pieter J. Rhijn. 1922.
26. "The Proper Motions of 3-Cephei Stars and the Distances of the Globular Clusters'.
27. Bulletin of the Astronomical Institutes of the Netherlands 1(8): 37-42. Kruit, Pieter C. van der. 2015.
28. Jacobus Cornelius Kapteyn: Born Investigator of the Heavens. Cham: Springer. Kruit, Pieter C. van der, and Klaas van Berkel, eds. 2000.

29. The Legacy of J.C. Kapteyn: Studies on Kapteyn and the Development of Modern Astronomy. Dordrecht: Kluwer. Lankford, John. 1984.
30. ''The Impact of Photography on Astronomy'. In The General History of Astronomy: Volume 4, Astrophysics and Twentieth-Century Astronomy to 1950: Part A, ed. by Owen Gingerich, Cambridge: Cambridge University Press, 16-39.-1997.
31. American Astronomy: Community, Careers, and Power, 1859-1940. Chicago: University of Chicago Press.Laurie, Philip S., Jacques Lévy, Aleksandr A. Mikhailov, Howard Plotkin, Deborah Warner Trudy E. Bell and Dieter B. Herrmann, 1984. 'Astronomical Institutions'.