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THE DISCOVERY OF THE CHANDRASEKHAR MASS AND THE CHANDRASEKHAR–EDDINGTON CONTROVERSY

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Abstract. The so-called Chandrasekhar limiting mass is a quantum mechanical relativistic effect. The discovery and establishment of the concept involved a major controversy between the young Chandrasekhar and the hilarious Eddington. We review the origin and evolution of the controversy.

Keywords: Chandrasekhar, Eddington, limiting mass, compact objects.

1. Introduction

A hot subject of research in the early 1920 was the distribution of the electrons in the various atomic shells. The correct electron arrangement in atoms was found by Edmund Stoner (1899–1968) in 1924. Based on optical spectra, Stoner attempted to find the arrangement of the electrons in the various levels. *It is remarkable,* stated Stoner, *that the number of electrons in each complete level is equal to double the sum of the inner quantum numbers as assigned. The electrons appeared to come in pairs which occupy the same quantum states.* Stoner's distribution of electrons was the distribution we know today, and as Stoner had already shown, it explained the chemical and the physical properties as they vary throughout the periodic table. In this distribution the electrons come in pairs, and not more than two occupy the same quantum state. However, Stoner went one step further and characterized the states of the electrons by two numbers: the first number was identical to the principal quantum number n of Bohr, and the second could take values from 0 to $n-1$. Indeed Stoner noted, that each electron has another l value.

Pauli's interest in the problem arose in 1922 when he met Niels Bohr. Bohr lectured in Göttingen on his new theory to explain the Periodic System of Elements. Right after Bohr came up with his model of the multi-electron atom, the following question arose: Why do all the electrons in the atom not fall to the lowest energy level? As a matter of fact, Bohr had already discussed this problem but could not find a satisfactory solution. A hint as to what goes on came when a strong magnetic field was applied to the atom. So far it was known that all electrons in a given shell possess the same energy. However, when a magnetic field was applied to the atom, the various sub-states within each shell obtained different energies. Very soon, Pauli realized that electrons immersed in a strong magnetic field have different quantum numbers and still do not descend to a lower state. However, he did not have a clue as to why this is so.

In 1923, Pauli returned to the University of Hamburg. The lecture he gave to obtain the title privatdozent was on the Periodic System of Elements expressed disappointment that the problem of closed electronic shells had no explanations. The only thing that was clear was the connection to the multiplet structure of the energy levels. According to the popular notion at that time, non-vanishing angular momentum had to do with doublet splitting. However, this was just a guess. In 1924 Pauli published some arguments against this point of view, in particular the two valued. At that time, the following essential remark by Stoner was published: *For a given value of the principal quantum number, the number of energy levels of a single electron in the alkali metal spectra in an external magnetic field is the same as the number of electrons in the closed shell of the rare gases which corresponds to this principal quantum number.* It is this sentence by Stoner, as Pauli wrote, which led him to the idea that: *The complicated numbers of electrons in closed subgroups are reduced to the simple number one, if the division of the group by giving the values of the four quantum numbers of an electron is carried so far that every degeneracy is removed. An entirely non degenerate energy level is already closed, if it is occupied by a single electron. States in contradiction with this postulate have to be excluded.* The general principle was finally formulated in 1925. In simpler words: in a given system of many electrons, no two electrons can have the same quantum numbers.

About twenty years later, the exclusion principle brought Pauli the Nobel prize. Stoner was not summoned to Stockholm.

2. Enrico Fermi & Paul Dirac

Enrico Fermi (1901–1954) was bothered by the fact that the equations of an ideal gas, in particular the expression for the heat capacity at constant volume, did not satisfy the Nernst (1864–1941) law, which demanded that you cannot reach absolute zero temperature in a finite number of steps. When Fermi saw the papers by Stoner and Pauli, he set out to find to what extent the application of the new principle to the molecules of an ideal gas yields an expression which satisfies Nernst's general principles. Interestingly, there was no mention in Fermi's paper of electrons, the particles to which the Pauli principle was applied. Eventually, Fermi discovered what is known today as the Fermi–Dirac statistics. Fermi and Dirac, independently, immediately grasped the far-reaching implications of the Pauli Exclusion Principle (PEP) for the gases of particles which obey it, such as electrons. With his fantastic physical intuition, Fermi derived his results directly, while Dirac, with his superb mathematical skills, derived the general theory of the behavior of quantum particles and derived both the Fermi result and the Bose–Einstein result, as special cases of his general theory.

It was Sommerfeld who applied the new statistics to the theory of metal and introduced the idea that the free electrons in a metal are a Fermi gas.

3. Eddington's white dwarf paradox

In his famous book, Eddington (1926) pointed to a paradoxical situation. As a star contracts the gravitational pull increases and, as a consequence, the temperature and the density of the gas must increase so as to counter-balance the increase in the gravitational pressure. At the same time, the star continues to lose energy from the surface. How can this be? Part of the gravitational energy goes into heating the gas and the rest is radiated away. So stars are unique objects, they lose energy all their life and as a consequence heat up! And inversely, stars cannot cool! As Eddington pointed out: to die by cooling, the star must lower its temperature and hence reduce its gas pressure, and in order to stay balanced it must decrease the gravitational pull, which it can do only by expansion or by having some extra source of energy which nobody had thought of. In Eddington's words: *We can scarcely credit the star with sufficient foresight to retain more than 90 % in reserve for the difficulty awaiting it. . . . Imagine a body continually losing heat but with insufficient energy to grow cold!*

The paradox shook the scientific community!

4. Cracking the paradox: Fowler

Ralph H. Fowler (1889–1944) was a leading physicist with contributions to statistical mechanics and astrophysics. Dirac's paper was communicated by Fowler to the Royal Society on August 26, 1926. On November 3, Fowler communicated his paper with the application of the laws of the 'new quantum theory' to the statistical mechanics of assemblies consisting of similar particles. By December 10 his paper entitled 'Dense Matter' was read before the RAS.

Fowler solved the paradox by applying Sommerfeld's theory of metals to stars. A star devoid of energy sources can reach zero temperature, and the pressure generated by the compressed electrons would be large enough to balance the weight of the stellar layers attempting to collapse inward.

Amazing. The temperature of a gas reflects the number of states the system can be in. The higher the temperature, the more states the system can be in. Here we find, à la Fowler, that white dwarfs are in the single lowest possible state, namely, all particles fill all the energy levels, exactly like the electrons in an atom. The gravitational force, which pushes the white dwarfs to this state appears to act in an opposite direction to thermodynamics. The star cools to the state of a white dwarf, and reaches the most ordered state with the lowest entropy.

In his obituary to Fowler, Chandrasekhar described this discovery as among the more important astronomical discoveries of our time. Fowler, in Eddington's language, allowed stars to die by cooling.

5. Pokrowski – the idea of a limiting mass

A surprising paper appeared in 1928 by the Russian scientist Pokrowski. Pokrowski assumed that the maximum density of the matter in the star is obtained when all fully ionized nuclei touch each other. Provided nuclei cannot be compressed, this should be the maximum density that matter can be in. This state is known today as 'nuclear matter'. Pokrowski estimated this density to be $\rho_{\max} = 4 \times 10^{13\pm1}$ gm/cm^3. Assume now a star with mass M and uniform density $\rho = \rho_{\max}$. It is simple to calculate the energy needed by a particle of mass m on the surface of the star to escape from the star to infinity. Since $\rho_{\max}$ is fixed, there exists a stellar mass M_{lim} for which the energy needed to escape exceeds the rest mass energy, and hence no energy/particle can leave this star and it cannot be observed. Pokrowski claimed that for $M > M_{\text{lim}}$ energy cannot leave the star. According to Pokrowski's calculations $M_{\text{lim}} = 30.29 M_\odot$. This was a pure classical calculation.

6. Anderson expands Pokrowski's idea but changes the reasons

Hardly a year after Pokrowski's publication, Wilhelm Anderson from Tartu University in Estonia, took Pokrowski's idea a bit further. Repeating the calculation without the new general theory of relativity, Anderson argued as follows: the luminosity that the star radiates is equivalent to the mass, so when the star radiates into space it contracts and decreases its mass. He therefore calculated how much mass a star loses as a function of the original mass before it reaches $\rho_{\max}$. For example, if the initial mass is $334\,M_\odot$ about $0.55\,M_\odot$ of the stellar mass is radiated before the star reaches $\rho_{\max}$, and if the initial mass is $4.82 \times 10^7\,M_\odot$, the final mass is $370\,M_\odot$ so that the amount radiated away is $1 \div 10^{-6} = 0.999999$ of the initial mass. Hence, concluded Anderson, the final mass of a star must be smaller than $370\,M_{\odot}$.

However, Anderson's most important contribution was the following: After sending the paper for publication, he became aware of Stoner's paper (see next) and remarked correctly in 'a note added in proof' that Stoner ignored the effects of special relativity, and hence his results are good only for small stellar masses.

7. Stoner: relativistic degeneracy leads to a limiting mass

At this point, Stoner entered the picture once more and published a sequence of papers in which the idea of a limiting mass gradually evolved. By now he was aware of the Pauli principle and of course of Fowler's work, which he applied. In the first paper Stoner developed the idea that there may exist a $\rho_{\max}$ not due to full ionization but due to the 'jamming' of the electrons which obey the Fermi statistics. Thus, the idea was basically that there exists a $\rho_{\max}$ which is smaller than the $\rho_{\max}$ derived by Pokrowski and Anderson. Stoner mentioned Jeans' stellar stability theory (which was not yet proven to be wrong) that a star cannot be stable if it satisfies the ideal gas laws. Hence, the matter in a stable star must be in a liquid state. Stoner also cited Jeans that atoms are fully ionized in white dwarfs, and claimed that it is electron jamming, rather than nucleus jamming, which results in the departure from the gas laws which ensure the stability of the star. So Stoner calculated the revised $\rho_{\max}$ caused by PEP. He adopted Fowler's theory and assumed a mean molecular weight of $\mu = 2.5$. To simplify the calculation, he used a constant density, like an incompressible liquid.

Stoner found a $\rho_{\max}$ beyond which the gravitational pull does not have the power to provide energy to the electrons so as to allow further contraction. The resulting density was found to be $\rho_{\max} = 3.85 \times 10^6\,(M/M_{\odot})^2$ gm/cm^3. Stars that reach this density cannot contract anymore, claimed Stoner, so they cannot extract energy from the gravitational field. They consequently become dark and their temperature is zero. All stars are doomed to die when their density reach $\rho_{\max}$. The comparison with observations was excellent and all known WDs had mean densities below $\rho_{\max}$. The mean density of Sirius B, for example, is 5×10^4 gm/cm^3 and Stoner got 2.77×10^6 gm/cm^3. The radii also agreed.

Stoner was happy with the results, because the electron gas in which all the energy levels are occupied is practically incompressible. In other words, it behaved like a liquid and hence satisfied Jeans' condition for the stability of stars. On the other hand, Stoner mentioned that his results had no effect on the difficulties that Jeans' condition implied for the stability of ordinary main sequence stars. There was no reference to Pokrowski, whose paper was published well before, or to Anderson, who published his paper roughly at the same time in the prestigious German Zeitschrift für Physik.

8. Anderson again

Soon after the semi critical paper on Pokrowski's limiting density, Anderson published an analysis of the state of the electron gas in white dwarfs in which he criticized Stoner's treatment of the problem. Anderson's most important contribution was that he noted that as the density increases the electrons are driven to higher energies and quickly become relativistic. Indeed, at a density of 10^6 gm/cm^3 the kinetic energy of the electron is already 0.28 of its rest mass energy. The inclusion of special relativity turned out to be crucial.

9. Stoner responds

Shortly after Anderson's paper was published, Stoner criticized his mathematical treatment, but accepted the basic idea that the role of the special theory of relativity is crucial. Stoner found the way to carry the calculation accurately. In particular, Stoner demonstrated that as the density tends to infinity the mass tends to a finite value M_{lim}.

Stoner did not discuss what happens to stars with masses $M > M_{\text{lim}}$. Do they contract forever? At a later time, Stoner attempted to improve the estimates of the limiting mass by assuming a polytropic equation of state. The pressure of the condensed electron gas varies as $\rho^{5/3}$ at low densities and as $\rho^{4/3}$ at high densities. The effect of special relativity is to reduce the power of the dependence of pressure on density by just 1/3. It is this change in the exponent which became the subject of a fierce and emotionally charged controversy between Chandrasekhar and Eddington. As a matter of fact, Stoner and Tyler managed to solve the case of low density but just missed the idea of assuming an ideal star in which everywhere the polytropic index is 4/3, as dictated by the special theory of relativity. Both papers were communicated by Eddington to the journal. In other words, Eddington communicated papers which included a result he objected to. Moreover, Stoner ended the paper with an acknowledgment to Eddington for proposing the problem of the 'upper limits'. When it came from Stoner, Eddington did not raise any objection or controversy.

I suspect that Stoner's cardinal contribution to white dwarf theory was not much recognized by astrophysicists (a) because it was published in the Philosophical Magazine, a journal that most of them did not read, and (b) because Stoner unfortrunately suffered from diabetes and poor health, which restricted his travelling and limited the presentation of his results in meetings.

10. Chandrasekhar

Chandrasekhar (1910–1995) met Sommerfeld in 1928 during Sommerfield's trip to India, and heard his seminar on the new theory of metals and the Fermi–Dirac statistics. At this time, Chandrasekhar decided to go to England and not to Germany, though the intention of Sommerfeld's visit to India was to strengthen the relations between German and Indian sciences. This preference for England over Germany had major consequences and a major impact on Chandrasekhar's life in the subsequent years. The story has it that while on the boat sailing to England, at the age of 19, Chandrasekhar applied Sommerfeld's theory of metals to white dwarfs. In doing so he generalized the Fermi–Dirac statistics to satisfy the demands of special relativity. Chandra effectively repeated Fowler's work with generalization to relativistic degeneracy. The basic difference between Stoner's limiting mass expression (which Chandrasekhar apparently was not aware of while on the boat) and Chandrasekhar's was that Chandrasekhar's included a better model for the density distribution in the star. The first result for the limiting mass obtained by Chandrasekhar was $0.91\,M_\odot$. Later, Chandrasekhar compared his result with Stoner's and concluded that: *The agreement between the accurate value based on the theory of the polytropes and the cruder form of the theory is rather surprising.* No word as to what may happen to stars more massive than $0.91\,M_\odot$ appeared in Chandrasekhar's two-page-long note.

Chandrasekhar's short paper about the limiting mass was published in the American ApJ, although the most important astrophysical works on the subject of stars were published at that time in the MNRAS. One can only wonder why Chandrasekhar chose this publication for his seminal contribution. Presumably he wanted to avoid a certain veto by Eddington. In 1934, Chandrasekhar summarized the physical state of the matter in the interior of stars by distinguishing between matter which obeys the ideal equation of state, dense matter which obeys the equation $P \sim \rho^{5/3}$, and ultra dense matter, which obeys the equation $P \sim \rho^{4/3}$. A limiting mass is obtained only for the ultra dense case. So Chandrasekhar classified the stars according to their mass. The very massive stars satisfy Eddington's equation, and the matter in them remains in the state of anideal gas. The matter in these stars depends only marginally on the PEP. On the other hand, the small masses were divided again into two classes. For stars with $M < (1.74/\mu^2)\,M_\odot$, the relativistic effects never become dominant and the density never exceeds $6.3 \times 10^5 \mu^5\,(M/M_\odot)^2$ gm/cm^3. Then came the white dwarfs. For white dwarfs with $M < 3.822\mu^2 M_\odot$, relativistic effects never play a role. White dwarfs in the mass range $1.743\mu^2\,M_\odot$ to $6.623\mu^2\,M_\odot$ reach a density in which relativistic effects play a dominant role. Finally, matter in stars with $M > 6.623/\mu^2\,M_\odot$ always obeys the ideal gas law. As for their fate, Chandrasekhar entered the territory for speculation and conjectured that as the density approaches the critical density the behavior of matter changes in an unknown way.

Until 1935, Eddington's attacks on Chandrasekhar were made in public and not in published papers. In 1935, Eddington published his first straightforward attack on the idea that special relativistic effects are important to the theory of white dwarfs. One may wonder what triggered Eddington and why he was so upset, to put it mildly, with Chandrasekhar's result. Maybe the answer can be found in the introduction to his paper: *Using the relativistic formula, he (Chandrasekhar) finds that a star of large mass will never become degenerate, but will remain practically a perfect gas up to the highest densities contemplated. When its supply of subatomic energy is exhausted, the star must continue radiating energy and therefore contracting – presumably until, at a diameter of a few kilometers, its gravitation becomes strong enough to prevent the escape of radiation. This result seems to me,* argued Eddington, *almost a reductio ad absurdum of the relativistic formula. It must at least rouse suspicion as to the soundness of its foundation.* In other words, Eddington did not believe in the physical reality of the Schwarzschild solution, just like Einstein, who refused to accept it as a physical solution. So, because he did not believe in what we call today black holes, he turned the argument round. Namely, if Chandrasekhar's theory leads to the formation of black holes, it must be wrong. Chandrasekhar definitely knew about Eddington's basic reasons for the objection to his results, and refrained from predicting the fate of a massive star in his communication to the RAS (February, 1934) and speculated about the nature of the interaction between the nuclei change at high density... In the paper Eddington set out to look for flaws in the derivation of the result $P \sim \rho^{4/3}$ for relativistic electrons. Eddington raised a series of technical questions and one fundamental one. The basic assumption of Fowler was that the electrons released from the atom in the star move freely in the entire volume of the star. This was one of Eddington's objections. Eddington did not argue with Fowler but with Chandrasekhar, who brought in special relativity (and got the limiting mass with its implications). In particular, Eddington claimed that Chandrasekhar combined special relativity with non-relativistic quantum mechanics.

The derivation made the (paradoxically correct) assumption that as the density rises the electrons move more like free particles in a spherical box. The nuclei do not affect the motion of the electrons, and consequently the electrons have a very long mean free path. This is exactly what happens in metals. We remark that Fowler did discuss this point and came to the conclusion that this assumption, however incredible it sounds, is correct. Möller and Chandrasekhar responded right away to Eddington's published attack. Actually, no wonder they could respond so quickly, as they acknowledged that they were: *are indebted to Sir Arthur Eddington for allowing them to see a manuscript copy of his paper.* As a consequence, the two papers appeared in the same issue of the MNRAS. A mere one volume later, the MNRAS carried Eddington's reply. Again, the arguments were mostly technical but his time the reply included a statement that: *the exclusion principle has been abundantly verified for electrons in the atom. Undoubtedly there exists a generalization of it applicable to large assemblies of particles* (he meant stars, G.S.) *but the generalization cannot be of the form assumed by Möller and Chandrasekhar, which conflicts with the uncertainty principle.* Eddington accepted Pauli's principle for atoms but rejected the extension to cosmic systems. Nobody else doubted the validity of the Pauli principle in stars. Moreover, this very statement contradicts Eddington's statements from 1916 about the validity of the laws of physics discovered on Earth in stars.

Chandrasekhar's final paper on the limiting mass with the new and rigorous derivation of M_{limit} for WDs was published in 1935. First, Chandrasekhar removed any references to radiation (symbolically, introducing radiation was Eddington's main achievement). Next, came the question: What happens to masses above the limiting mass? What Chandrasekhar had hesitated to state in the previous paper he dared to write now: *configurations of greater mass must be composite (which means Milne's models) these composite configurations have a natural limit . . . zero radius.* In a footnote, Chandrasekhar added that: *In the previous paper this tendency of the radius to zero was formally avoided by introducing a state of 'maximum density' for matter, but now we shall not introduce any such states, namely for the reason that it appears from general considerations that when the central density is high enough for marked deviations from the known gas laws to occur, the configuration then would have such small radii that they would cease to have any practical importance in astrophysics.* In other words, Chandrasekhar did not believe at that time in the reality of what we today call black holes. However, Chandrasekhar changed his mind years later. In his concluding remarks, he stated that white dwarfs are the limiting sequence of configurations to which all stars must tend eventually. How more massive stars would behave was not elaborated.

In 1939, Chandrasekhar closed his chapter on WD when he summarized his results in a book. In the chapter on quantum statistics, Chandra added a note: Eddington claimed in 1935 that the partition function used in this book is incorrect. *However, the investigation by Möler and me failed to support it. The general theory presented in this chapter is accepted by theoretical physicists.* When Chandra derived M_{limit} there is no further mention of Eddington.

After Eddington published his attack in 1935, his claims became explicit. In 1936, Chandrasekhar recruited Rudolf Peierls (1907–1995), a leading nuclear physicist, to write a note on the derivation of the equation for a relativistic gas. Peierls discussed Eddington's contentions that the behavior of the gas in the star may depend on the shape of the volume inside which it moves. *As a matter of fact,* Peierls admitted that *the issue is so simple that there is no need to elaborate on it. Yet, some,* and they did not mention Eddington, *still argue to the contrary.*

Eddington's last paper on WD matter was published in 1940. The paper contains Eddington's contention including statements such as *quantum theory, unlike relativity theory, is not primarily a rational theory, and therefore its formulae are generally enunciated without any indication of the conditions in which they are valid. A formula established empirically in certain conditions is extended to conditions in which is has not been verified by a procedure known as "the principle of induction" or less euphemistically as "blind extrapolation". Such extrapolation, though often leading to progress, is fairly sure to breakdown sooner or later . . . but the limits of application are not derived along with the formulae in a rational theory.* By then, Eddington was immersed in his metaphysical theories and nobody paid attention to his paper.

11. The personal side

So far we have discussed what appeared in the professional literature. But the controversy between the two scientists had unpleasant personal sides. We see a conflict between two extreme personalities. On the one hand Eddington, a dominant figure in astrophysics, who had won every possible medal and prize, and on the other hand, a young unknown scientist who had recently completed his PhD thesis. It eventually turned out that the controversy propelled Chandra to a position of scientific eminence.

Despite his eminence, Eddington was easily accessible in Cambridge, and Chandrasekhar had many scientific conversations with him. But private friendship and public relations are quite different matters. When Chandrasekhar went early in 1935 to a meeting of the Royal Society to report his results, he noticed to his surprise that Eddington was listed to talk after him. And indeed, after Chandrasekhar finished his talk, Eddington took the podium and tried to prove that *there is no such a thing as 'relativistic degeneracy'.* Eddington in effect ambushed Chandra, as he had given him no warning that he was going to attack and humiliate him in public. Moreover, to argue against someone's scientific result is one thing but to joke at the expense of a rival is another thing, and Eddington joked about Chandra's colossal error. A similar scene happened later that year during the IAU meeting in Paris. It was clear that Eddington had publicly vanquished Chandrasekhar to the point that he could not get any position in Europe. The community believed that Eddington was right, namely *Nature could not behave the way Chandrasekhar predicted . . .* Eddington argued that it was heresy. There are claims that Henri Norris Russell, who was the chairman of the session, told Chandra in private that he did not believe Eddington, but he did not let Chandra respond to Eddington's assault.

Eddington had a very special language and reasoning in his scientific papers and managed to fight with many during his scientific career. His sarcasm only added oil to the fire.

Chandrasekhar had excellent relations with Milne, appreciated his core-envelope models and discussed his first results in terms of Milne's model, to which Eddington objected bitterly. Eddington detested Milne and disapproved of his stellar model and admitted that: *I have not read Professor Milne's paper, but I hardly think it is necessary, for it would be absurd for me to pretend that Professor Milne has the remotest chance of being right.*

In 1931, Chandrasekhar extended his research in two directions: in a paper communicated by Milne, he expanded Milne's theory of collapsed objects (a collapsed core surrounded by a stellar envelope – non-homogeneous star), and attempted to explain the structure of white dwarfs. At the end of this paper, Chandrasekhar gave a table in which he distinguished between the fate of low mass stars and high mass stars. This is one of the first times that the fate of a star was considered as a function of its mass. In parallel, he worked on his theory of bare white dwarfs. It so happened that the paper on Milne's composite models came out just before Chandrasekhar submitted his paper about the critical mass of white dwarfs. Needless to say, these papers did not please Eddington.

Chandra had excellent relations with Dirac, who advised him to go to Copenhagen, where there were *many good physicists.* Indeed Chandra did go to Copenhagen. He summarized his grievances in a letter to Leon Rosenfeld, asking the verdict of Bohr and his gang. Rosenfeld's response was disappointing: *I may say that your letter was some surprise for me: for nobody had ever dreamt of questioning the equations, and Eddington's remark as reported in your letter is utterly obscure. So I think you had better cheer up and not let you scare so much by high priests: for I suppose you know enough Marxist history to be aware of the fundamental identity of high priests and mountebanks ... So, if "Eddington's principle" had any sense at all, it would be different from Pauli's. Could you perhaps induce Eddington to state his views in terms intelligible to humble mortals? What are the mysterious reasons of relativistic invariance which compel him to formulate a natural law in what seems to ordinary human beings a non-relativistic manner. That would be curious to know.*

Amazingly, a respected list of physicists knew that Eddington was wrong, but chose to stay away from controversy.

A point of concern. Stoner's work is essentially identical to that of Chandra. Yet Eddington chose to make his ferociously attack on the young astrophysicists and did not mention at all the already mature Stoner. Landau derived Chandra's result independently (though for neutrons), and Eddington did not attack him.

The moral: Eminent scientists are not immune against making colossal mistakes and perusal biases.

Chandrasekhar was awarded the Nobel prize in 1983. By then, had Stoner met his creator. It is a pity that there was no prize for Stoner.

References

[1] For detailed reference see: Giora Shaviv, *The Life of Stars*, Springer & Magnes Pub., 2009