The Discovery of the “Chandrasekhar mass” and the Chandrasekhar-Eddington controversy

Giora Shaviv , Technion

ife of Stars
ontroversial Inception and Emergence of the Theory of Stellar Structure

beautifully illustrated book describes the birth and evolution of the ory of stellar structure through the vehement controversy between biol- (as presented by Darwin) and physics (as presented by Kelvin) about the of the Earth, which culminated with Rutherford suggesting radioactive ng. Shaviv analyzes critically many proclaimed scientific results, show- how and why they were wrong, and explains why it took decades to find how accepted scientific answers – where there are such – and why there ains much more to be done before we can say we fully understand what pens up there in the heavens.

Life of Stars provides fascinating reading for all those interested in the , in the history of astronomy and in what their story tells us about how nce progresses. Moreover, it will bring readers up-to-date on current lems in astrophysics.

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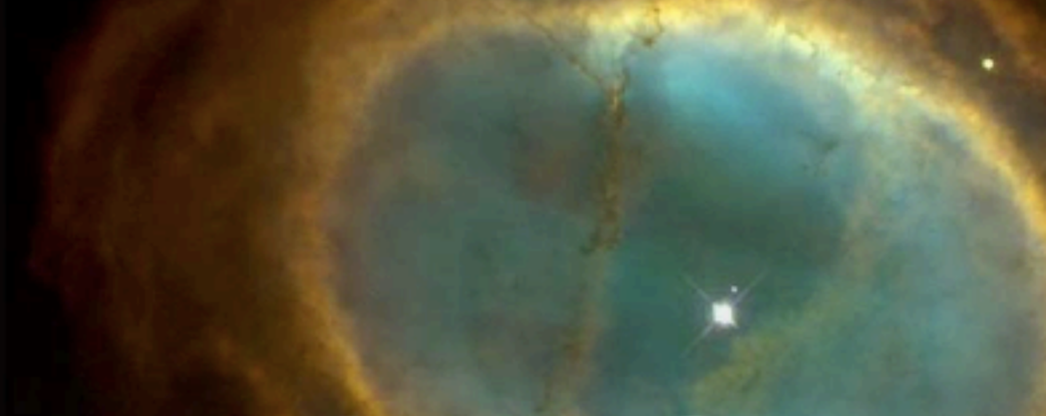
The Life of Stars



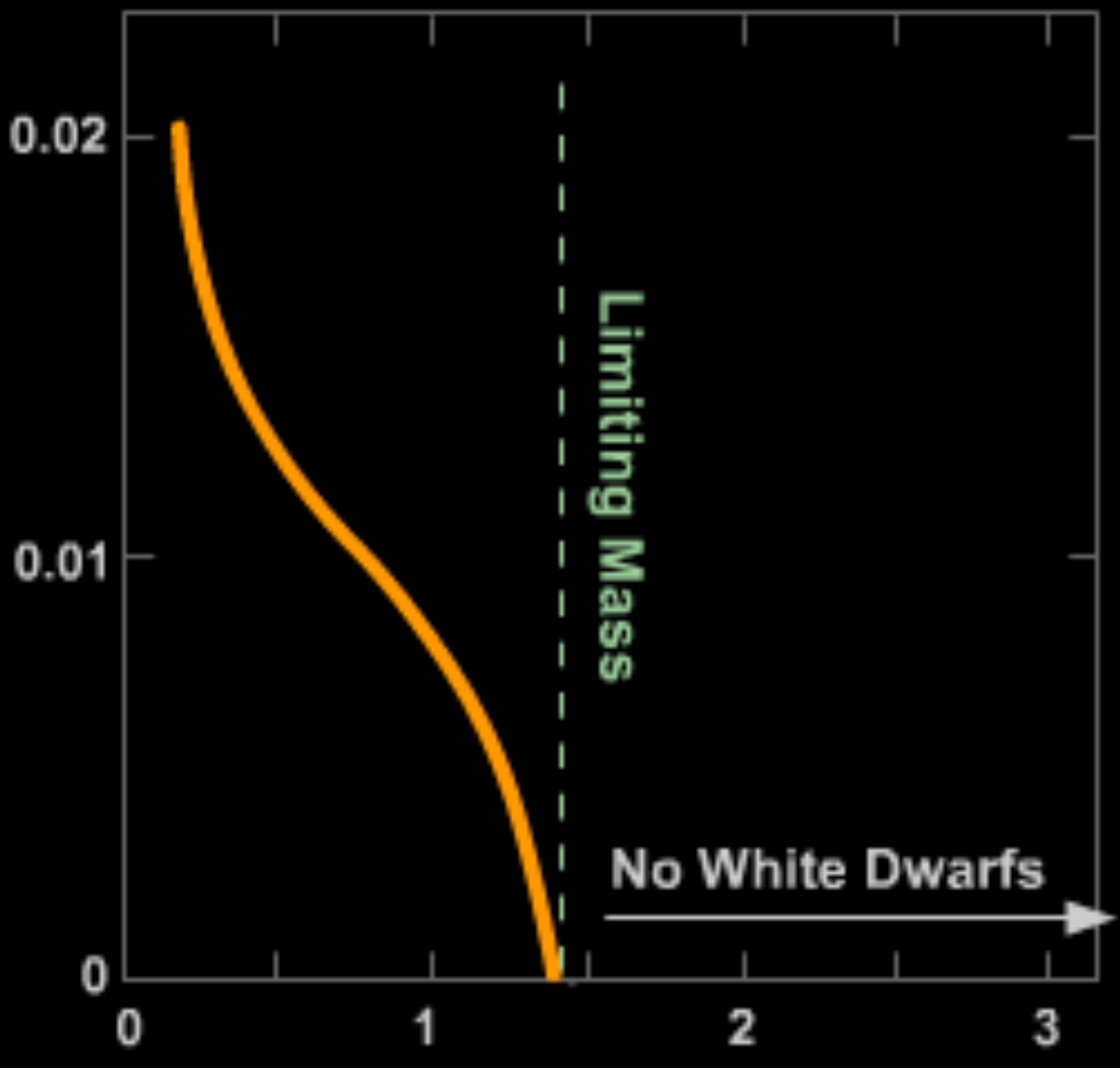
Giora Shaviv

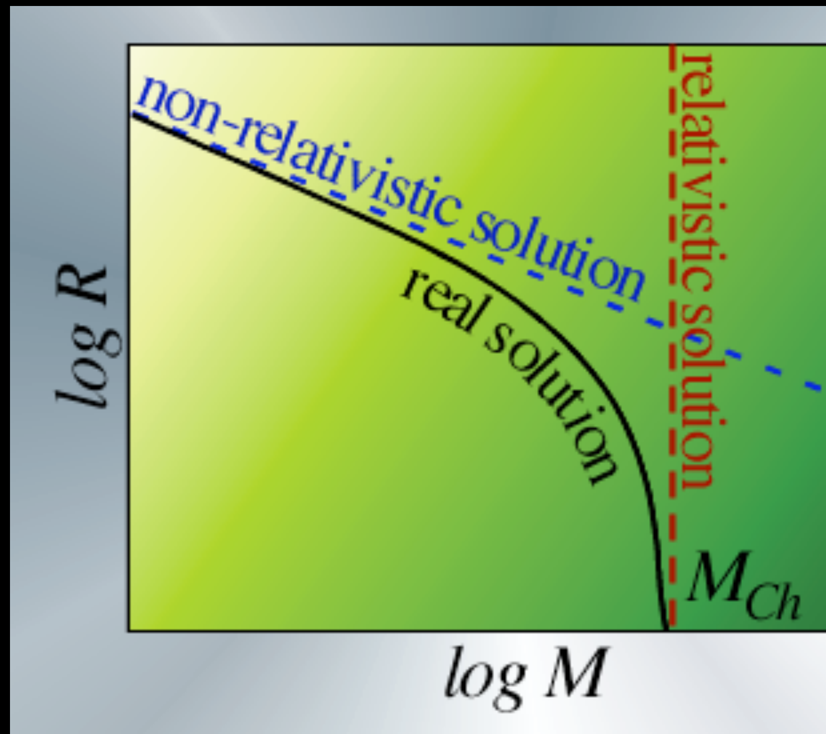
The Life of Stars

The Controversial Inception and Emergence of the Theory of Stellar Structure

Springer

quantum+special relativistic effect





he plan of the talk

he discovery of the exclusion principle (Pauli & St

he application to the theory of metals Statistics
ermi, Dirac Sommerfeld, Fowler)

rom metals to stars (Fowler)

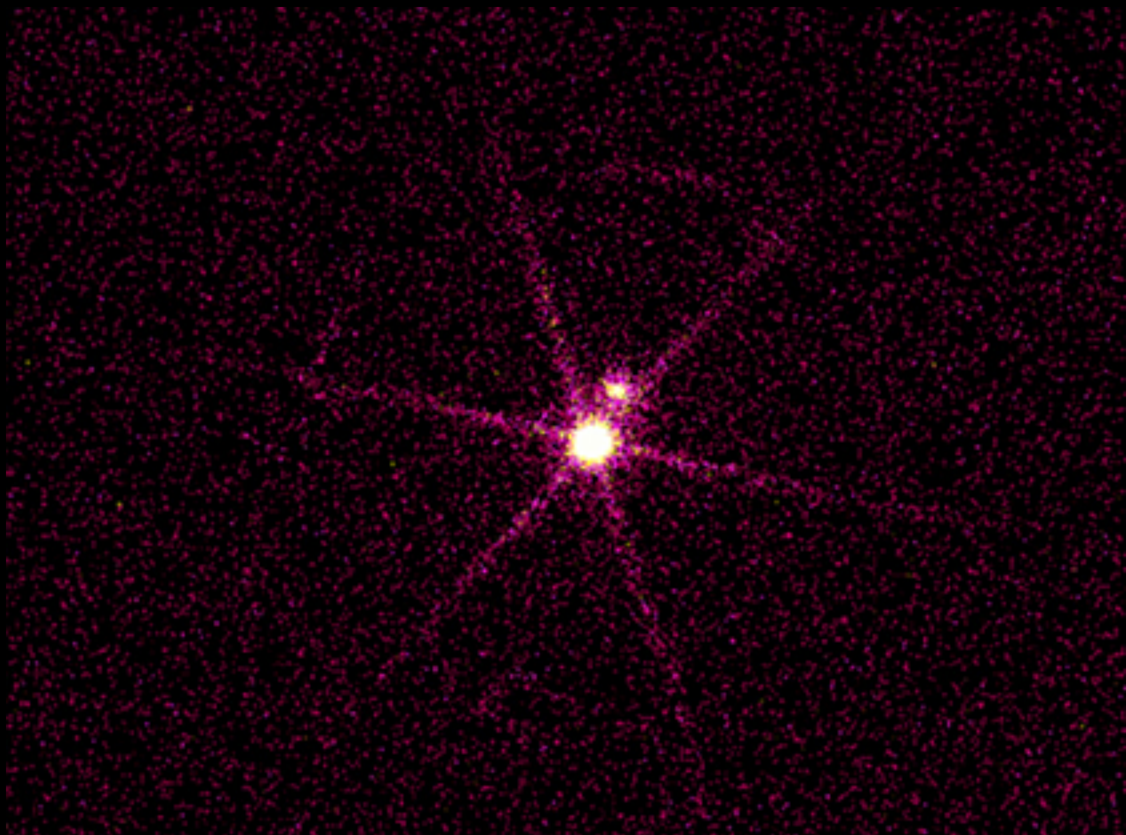
eas about a limiting mass and the need of relativity
Pokrovski, Anderson, Stoner)

Chandrasekhar & Eddington

What was the controversy about and why did he bizarre way some great personalities may behav

The star that caused the commotion in astrophysi

Sirius A & B



The foundation: The Pauli Exclusion Principle 1924

How Stoner' s contribution was neglected

The Fermi-Dirac statistics 1926

Ralf Fowler: The merger of Fermi-Dirac with gravit

Solution of Sirius B - 1926

The hypothesis of the existence of a limiting mass

t was not by Chandrasekhar - guess who got it fir

Edmund Clifton Stoner (1899-1968)

Wolfgang Pauli (1900 – 1958)

The man who was not awarded two Nobel prizes -

Nobel prize 1945

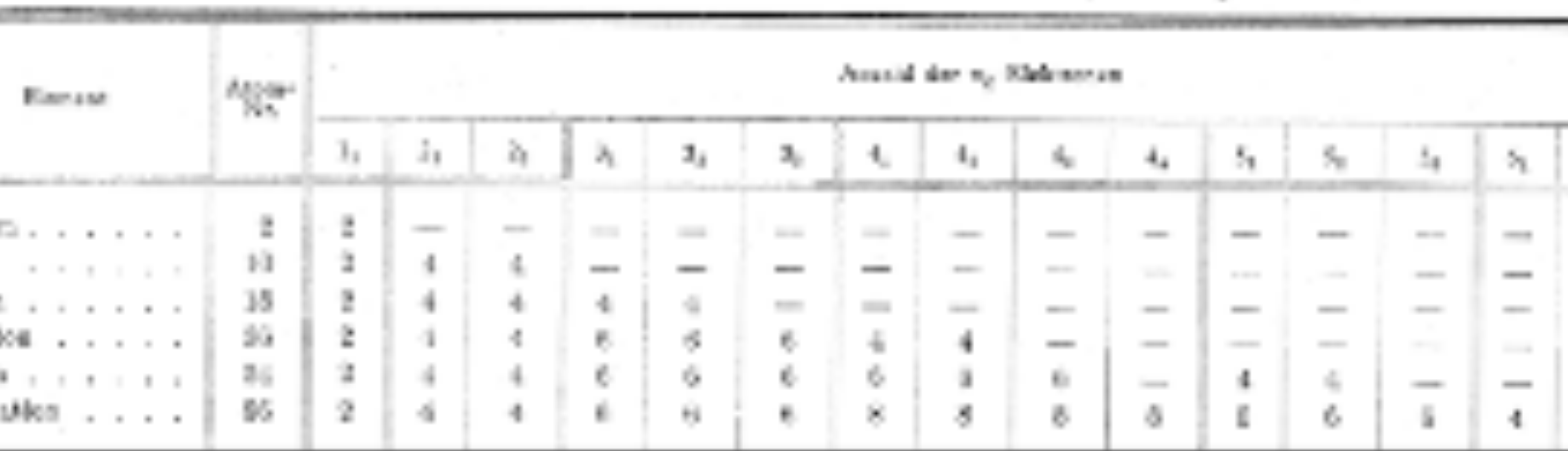
ect arrangement of the electrons in the atomic sh

t electron arrangement in atoms found by Edmund Stoner (1899-1968) in 1924.
on optical spectra, Stoner attempted to find the arrangement of the electrons in the
s levels.
reviewed previous trials to find the distribution of the electrons and showed that non of
pposed schemes worked. It is remarkable stated by Stoner, that:

mber of electrons in each complete level is equal to double the sum of the inner quantum
gned. The electrons appeared to come in pairs which occupy the same quantum states.

s distribution of electrons was the one we know today and as Stoner had already shown
ed the chemical and the physical properties along the periodic table. In this distribution
ns come in pairs, and not more than two occupy the same quantum state.

went one step further and characterized the states of the electrons by two numbers, the
e was identical to the principal quantum number n of Bohr, and a second one could take
to n – 1. Stoner indeed noticed, that each electron has another *l* value.



Element	Atom-Nr.	Anzahl der n_k Elektronen													
		1_1	2_1	2_2	3_1	3_2	3_3	4_1	4_2	4_3	4_4	5_1	5_2	[illegible]	[illegible]
[illegible]	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—
[illegible]	[illegible]	2	4	4	—	—	—	—	—	—	—	—	—	—	—
[illegible]	[illegible]	2	4	4	4	4	—	—	—	—	—	—	—	—	—
[illegible]	[illegible]	2	4	4	6	6	6	4	4	—	—	—	—	—	—
[illegible]	[illegible]	2	4	4	6	6	6	6	[illegible]	6	—	4	4	—	—
[illegible]	[illegible]	2	4	4	6	6	6	8	8	8	8	[illegible]	6	[illegible]	4

The electron arrangement as found by Stoner and confirmed by Pauli sequence of 2,8,18... of the electrons and failed.

t time the following essential remark by Stoner was published: For a given value
principal quantum number is the number of energy levels of a single electron in the alka
a in an external magnetic field the same as the number of electrons in
osed shell of the rare gases which corresponds to this principal quantum number.

is sentence by Stoner, as Pauli wrote, which led him to the idea that:

omplicated numbers of electrons in closed subgroups are reduced to the simple number o
on of the group by giving the values of the four quantum numbers
electron is carried so far that every degeneracy is removed . An entirely non degenerate
ady closed , if it occupied by a single electron. States in contradiction with this postulate
led.

eneral principle was finally formulated in the spring of 1925 in Hamburg.
pler words: in a given system of many electrons, no two electrons can have the

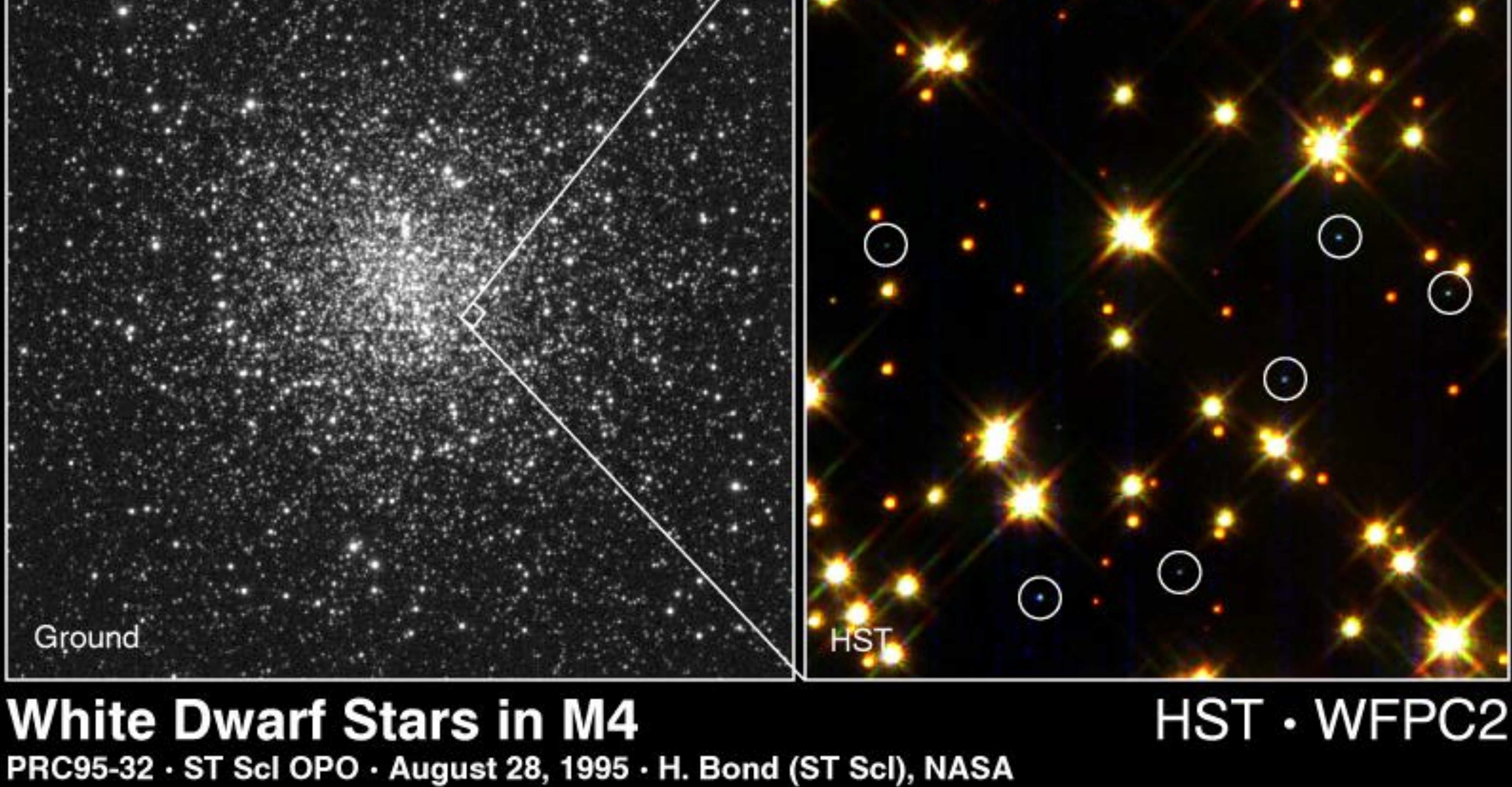
26: Fermi & Dirac appreciate the meaning the PE

ermi wanted to satisfy Nernst law: you cannot reach absolute zero temperature in a finite number of steps.

No mention of electrons in the paper

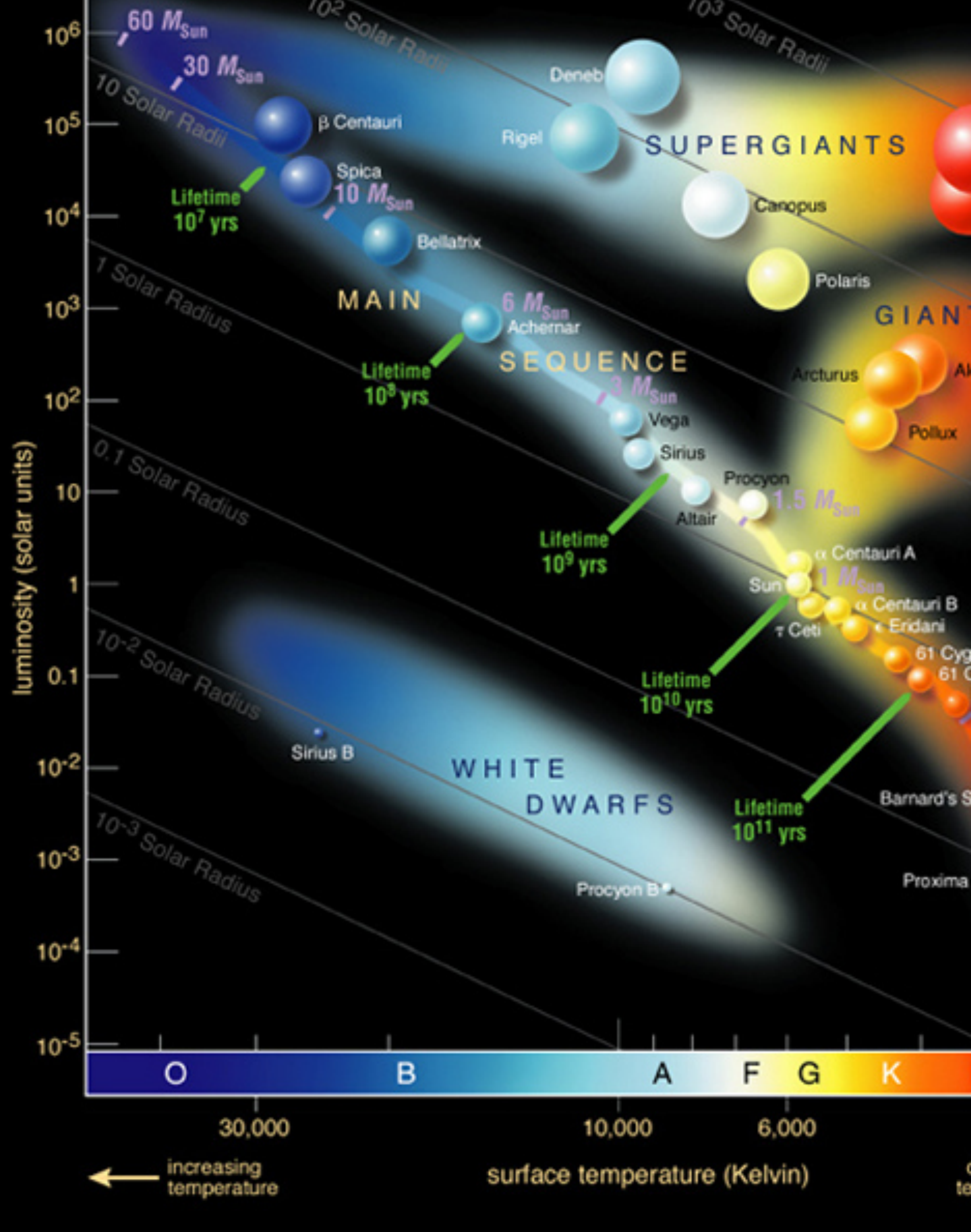
ording to Pauli (1944) the connection between spin and statistics is one most important application of the special theory of relativity theory.

Note the intimate connection PEP and special



Now to the sky

e WD appeared as
oling objects and
 was a problem to
ington



alance: Pgrav=Pgas

Upon contraction Pgrav ↑ and hence Pgas ↑ heating!

f the gravitational energy goes into heating of the gas (to c

rs contract, lose Egrav and heat up. Hence they cannot (cool

ounter balance) and the rest is radiated away. So stars are ur

ts, they lose energy all their life and as a consequence heat

nversely, the stars cannot cool!

Eddington's words: We can scarcely credit the star with suf

sight to retain more than 90% in reserve for the difficulty

iting it. ...Imagine a body continually losing heat but with

fficient energy to grow cold!.

ph Howard Fowler(1889-1944m) was a
ing physicists with contributions to
istical mechanics and astrophysics.
925 he worked out with Guggenheim on the
erties of stellar material assuming that the gas
tars behaves like an ideal gas. Fowler had also contribution
heory of stellar spectra. Fowler was the first to apply the
ni-Dirac statistics to WD.

ler served as a lieutenant in the Royal Marine Artillery and was seriously
nded during the battle of Galipoli, a battle in which Moseley lost his life.
ler married Eileen, Rutherford's only daughter.

s paper that contained the derivation of what has since then been named ' Fermi-Dirac statistics ' , was communicated by Fowler to the Royal Society on August

vember 3, Fowler communicated a paper of his own in the application of the laws of the ' new quantum theory ' to the statistical mechanics o blies consisting of similar particles was systematically ped and incorporated into the general scheme of the Darwin-Fowler method.

cember 10 his paper entitled ' Dense Matter ' was read before the Royal Astronomical

er solved the Eddington's paradox by applying the Fermi-Dirac statis er at high densities. What Fowler found was that the ultimate state wa n which the star can be considered as a gigantic atom with only one guration. The star, if it is devoid of energy sources, can reach zero erature and the pressure generated by the compresses electrons wo enough to balance the weight of the stellar layers attempting to colla d due to the gravitational pull like a quantum system! This is part of Eddington's problem to accept

Eddington did not attack Fowler

assumed that all atoms were stripped of their electrons and the electrons roam freely in t
was shown before by Eddington.

re star is strictly analogous to one gigantic molecule in its lowest quantum state.

est quantum state Fowler meant that all states are occupied like in an atom on the Earth.

Sommerfeld included quantum statistics in Lorentz+Drude metal theory.
at Fowler's idea to see the entire star as a single system or as a piece of metal (but with
of their electrons) in which the Fermi-Dirac statistics plays the dominant role, preceded
ion of the Fermi-Dirac statistics to metals.

asekhar, in his obituary to Fowler, described this discovery as among the more importar
stronomical discoveries of our time. Indeed, Fowler's application of the Pauli Exclusion
e in the form of the Fermi-Dirac statistics changed stellar evolution forever. Fowler, in
on's language, allowed stars to die by cooling.

If you think that Fowler got the Nobel prize

ndirectly correct idea but
ompletely wrong arguments

ut of the blue, a Russian author, Pokrowski appeared.

ski: the maximum density of the matter in the star is obtained when all atoms lose their e
nuclei touch each other. Provided nuclei cannot be compressed,
found later to be the case, this should be the maximum density matter can be in. This stat
oday as ʹ nuclear matter ʹ. Pokrowski estimated this density to be
3 ± 1 gm/cc.

he maximal density is fixed, there exists a stellar mass for which the energy
to escape exceeds the rest mass energy $E = mc^2$, and hence no energy/particle can leave
nnot be observed. According to Pokrowskiʼs calculations, this mass is 30.29 M⊙.

skiʼs calculation was based on Newtonian mechanics . In a way, Pokrowski essentially r
uries old calculation by Laplace who discussed the idea that the limiting state of a star is
e as to prevent the light from escaping it

azing:

en years after the discovery of general relativity by Einstein and 12
after Schwarzschild discovered his solution to the general theory of relativity, there was
ation to carry out a calculation which ignored completely general relativity. Moreover,
vski formulated his result by stating that:

ong gravitational field curves the space around the star in an extraordinary way which is
ge of the general theory of relativity. So it is plausible to assume that Pokrowski knew ab
l Relativity and still published a wrong calculation.

here was no reference to Fowler's seminal work. On the contrary, Pokrowski adopted
ton's assumption for stars on the main sequence, namely that the stars behave like ideal

asons

y a year after the publication of Pokrowski's 3 pages long paper, Wil
rson from Tartu university in Estonia, took Pokrowski's idea a bit furt
ating a calculation without GR, Anderson argued as follows:

minosity that the star radiates is equivalent to mass, so when the sta
es into space it decreases its mass. (Forgot Jeans)

lculated therefore, how much mass a star loses as a function of the
al mass before it reaches the limiting density. For example, if the initi
is 334 M☉ about 0.55 M☉ of the stellar mass is radiated before the st
es the limiting density and when the initial mass is 4.82×10^7 M☉ the
is 370 M☉ so that the amount radiated away is
0^{-6} = 0.999999 of the initial mass. Hence, concluded Anderson, the f

erson then criticized Eddington's claim that the gravitational contraction energy is fficient to support the Sun for billions of years. The contraction, claimed Anderson, be so high that it can easily supply all the energy the Sun needs in its lifetime.

erson was right from the point of view of the energy balance.

uclear transmutation of hydrogen into helium about 0.007 of the rest mass is verted into energy. So if gravitational contraction can supply the entire rest mass, ould be able to supply a small part of it.

ever, Anderson did not carry out a calculation of the lifetime of the Sun and did r to the necessary changes in the radius of the Sun, had it really derived its energ traction. As a matter of fact, except for references to Pokrowski, Eddington, and he value of the constant of gravity), Anderson chose to ignore all previously pub lts. After sending the paper for publication, Anderson became aware of Stoner's remarked correctly in 'a note added in proof' that Stoner ignored the change e mass of the the electron due to special relativity and hence his results ar for small stellar masses. Anderson was right about this point.

point Stoner re-entered the picture and published a sequence of papers in the idea of a limiting pass evolved gradually.

r developed the idea that there may be a limiting density not due to nuclei los lectrons but due to the ′jamming′ of the electrons which must obey the Fermi cs.

r: There exists a limiting density which is smaller than the one assumed by wski and Anderson. Stoner mentioned Jeans stellar stability theory (which wa et proven to be wrong) that a star cannot be stable if it satisfies the ideal gas e, the matter in a stable star must be in a liquid state. Stoner cited from the newl hed book by Jeans that: In white dwarfs atoms are mainly ionized down to their heir jamming, rather than that of the nuclei, which results in the departure from t hich ensure the stability of the star.

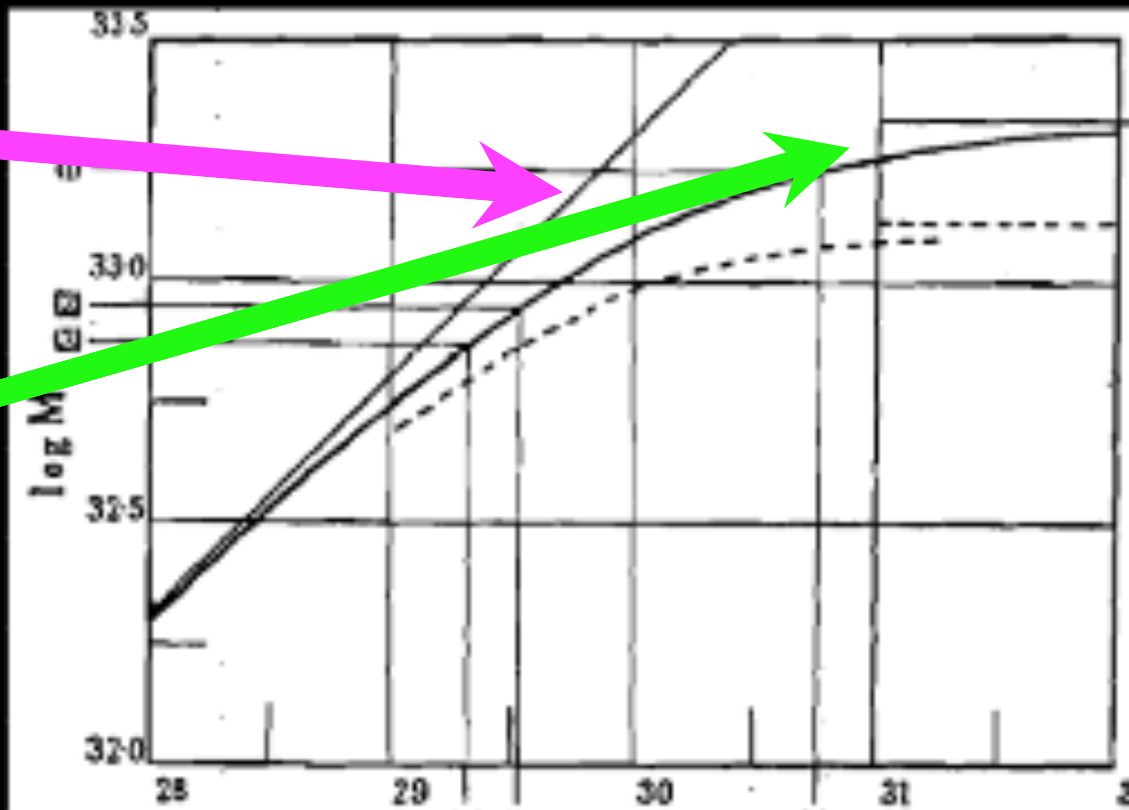
oner adopted the new theory of Fowler and assumed that the mean molecular we te dwarfs is 2.5. To simplify the calculation he assumed that the density in the st n and does not change from the high density in the center to vanishing density o e. If the star behaves like a liquid, this assumption is logical.

in criticism Stoner had been on the accuracy of the approximations Anderson and not on the idea that relativity is important. Stoner found the way to carry the tion accurately (by using the energy of the particles instead of the mass). Again, ed a mean molecular weight of 2.5.

a of a limiting mass due to relativistic degeneracy appeared for the first time in t and the approximate value for it is very close to the accurate one. The effect of ecial theory of relativity is clearly seen. Without incorporating relativity the curve d was the straight line which shows no signs of ʹsaturationʹ or tending to a finite ass.

o Special relativity

th special relativity



e the power to provide the energy to the electrons so as to allow fu
raction. The resulting density (for a molecular weight of 2.5) was fo
e:

$$\rho = 3.85 \times 10^6 (M/M_{sun}) \text{gm/cc}$$

r: Stars that reach this density cannot contract anymore, so they cannot extract
he gravitational field and consequently they do not shine, they are dark and at ze
erature.

mean density of

s B is 5×10^4gm/cc,

ni B is 9.8×10^4 gm/cc,

Maanen's star has a mean density in excess of 10^5 gm/cc

von B has a mean density of several thousands.

mass of Sirius B is $0.85 M_\odot$, then according to Stoner the maximum density shou

× 10^6gm/cc and

ni B with a mass of $0.44 M_\odot$gm/cc should have a maximum density of 7.48×10^5g

e the temperatures of the stars are not yet zero, it appeared that the observed
ties agree nicely with the predictions of the theory. Moreover, if the density in the
that can be compared with observations. Indeed, the minimal radius of Sirius B w
lated to be $0.0075\ R_\odot$, while the observations yielded $0.03\ R_\odot$.

ridani B the minimal theoretical radius was $0.011\ R_\odot$, while the
rved was $0.018\ R_\odot$. Every star has a minimal radius, and it cannot contract beyo
radius. $\rho = 3.85 \times 10^6$ gm/cm3.

er assumed that white dwarfs, which are at the end of the st
ution, are composed of lead, and the mean molecular weight
ed lead is 207.2/(82 + 1) = 2.50. Jeans derived a molecular
6 because he assumed the matter of the dwarf stars to be
posed of uranium.

lid not discuss what happens to stars which are more massive than the limiting mass. D forever? At a later time (1930) Stoner attempted to improve the estimates of the limiting to account the density distribution. To that goal he applied the model polytropes from E asgugeln monogram. His result was 1Msun.

ssure of the condensed electron gas varies like $\rho^{5/3}$ at low densities and as $\rho^{4/3}$ at high s.

change in the exponent which would be the subject of the fierce and emotionally charg up controversy between Chandrasekhar and Eddington.

s papers were communicated by Eddington to the journal.

on communicated papers which included a result he objected to. Moreover, Stoner ende ith acknowledgment to Eddington for proposing the problem of the 'upper limits'.

ct that partly the reason why Stoner's cardinal contribution to the theory of white dwarf zed by astrophysicists is because of its publication in The Philosophical Magazine, a jou ently read by astrophysicists.

Despite his objection to the result,

asekhar (1910-1995) met Sommerfeld in 1928 during Sommerfeld's trip to India and hea
on the new theory of metals and the Fermi-Dirac statistics.

asekhar even got the galley proofs of the new book from Sommerfeld. Chandrasekhar ap
ory of metals to stars. The reverse of Fowler!

ime Chandrasekhar decided to go to England and not Germany though the intentions of
rfeld's visit to India were to strengthen the relations between German and Indian science
ision might have been affected by the language barriers.
ference of England over Germany had major consequences and impact on Chandrasekha
ing years.

e being on the boat going from India to England, at the age of 19,
ndrasekhar worked out the limiting mass of white dwarfs,
rk that granted him the Nobel prize in 1983 (Stoner died in 1968)

basic difference between Stoner's limiting mass expression (which
ndrasekhar apparently was not aware of while on the boat) and
ndrasekhar's was that the latter included a better model for the
ity distribution in the star and consequently, obtained a supposedly m
rate value for the limiting mass. Indeed, the first result for the limiting
s obtained by Chandrasekhar was $0.91M_\odot$.

Chandrasekhar compared his result with that of Stoner and concluded that:

greement between the accurate working out, based on the theory of the polytropes,
e cruder form of the theory is rather surprising.

rasekhar knew about Eddington's objection to the idea of a limiting mass,
vo page long note was published in the American Astrophysical Journal although the
ant astrophysical literature on the subject of stars was published at that time was the
ly Notices of the Royal Astronomical Society.

uld be noted that Chandrasekhar used to write long and comprehensive papers and th
limiting pass was exceptionally short by Chandrasekhar standards.
an only wonder why Chandrasekhar chose this venue for his seminal contribution.

e piquant side, Chandrasekhar was Fowler's PhD student in Cambridge and got the
3 and his limiting mass prize winning paper was published while he was still a gradu
t.

summary, what Stoner first and Chandrasekhar second
t independently proved was that cold stars are stable for
asses smaller than the limiting mass, while more massive
rs are apparently unstable.

ddington argued that there is no such a thing as
"relativistic degeneracy"

1935 Eddington published the first straightforward attack on the
ea that special relativistic effects are important to the theory of
hite dwarfs.

dington argued that Chandrasekhar combined spe
relativity with non relativistic quantum mechanics

One may wonder what triggered Eddington's and why he was upset, to put it mildly, with Chandrasekhar's result.

May be the answer can be found in the introduction to his pape
Using the relativistic formula, he (Chandrasekhar) finds the a s
of large mass will never become degenerate, but will remain
practically a perfect gas up to the highest densities contemplat
When its supply of subatomic energy is exhausted, the star mu
continue radiating energy and therefore contracting - presumab
until, at a diameter of a few kilometer, its gravitation becomes
strong enough to prevent the escape of radiation.

This result seems to me almost a reductio ad absurdum of the
relativistic formula. It must at least rouse suspicion as to the
soundness of its foundation.

ington and appreciated Milne's core-envelope mo

dington detested Milne and disapproved of his mo

He
itted
at:

"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 has the remotest chance of being right."

Chandrasekhar had almost a daily contact with
ddington and told him about his results. Eddington
never attacked or criticized Chandrasekhar in
private, always in public in front of great audience

other words, Eddington did not believe in the physical reality of th
chwarzschild solution, exactly like Einstein who refused to accept i
hysical one.

o, because he did not believe in what we call today black holes, he
rned the argument namely, if Chandrasekhar's theory leads to the
rmation of black holes, it must be wrong.

y guess is that Chandrasekhar knew about Eddington's basic reas
r the objection to his results and for this reason refrained from
edicting the fate of massive star in his communication to the Roya
stronomical Society (February, 1934) and speculated about the na
the interaction between the nuclei change at high densities

andrasekhar refrained from visiting England for m
years.

The final victory

o far we discussed what appears in the professiona
literature.

Royal Society dinner , June 12, 1936.
Chandra is Eddington' s guest and sits by him

Royal Society meeting

1935 IAU Paris meeting: Eddington claims
"Chandrasekhar result is simple heresy"

There is no such a thing as relativistic degeneracy

ohr, Pauli and Dirac

osenfeld response:

ay say that your letter was *some* surprise for me: for nobody had ever amt of questioning the equations, and Eddington's remark as reported your letter is utterly obscure. So I think you had better cheer up and let you scare so much by high priests: for I suppose you know ough Marxist history to be aware of the fundamental identity of high ests and mountebanks.....

if "Eddington's principle" had any sense at all, it would be different from Paul uld you perhaps induce Eddington to state his views in terms intelligible to hu rtals? What are the mysterious reasons of relativistic invariance which compel mulate a natural law in what seems to ordinary human beings a non-relativistic nner. That would be curious to know.

enfeld, Bohr and Pauli unwilling to challenge Edding

he relations between Eddington and Chandrasekha
emained warm and cordial. They exchanged letters

936 Chandrasekhar recruited Rudolf Peierls (1907-1995), a
ing nuclear physicist, to write a note on the derivation of th
ation for a relativistic gas. This time the paper was
municated to the MNRAS by Chandrasekhar.
e end though it was Chandrasekhar who had to thank Peier
rls discussed Eddington's contentions that the behavior of
in the star may depend on the shape of the volume inside w
rls admitted that the solution was obvious, but in view of th
roversy it is perhaps worthwhile to give a proof.

cknowledgment to Chandrasekhar appeared at the end thou
as Chandrasekhar who had to thank Peierls.

spite the fact that Chandrasekhar was invited to g
ted talks on the limiting mass, Eddington exercised
ormous influence and prevented Chandrasekhar fr
g invited to international conferences. It was clear
ndra had no future in England and he left for the U
and did not return to England for over 30 years.

he idea of Milne, as described by Landau, was that if L and M are chosen to be
etely arbitrary, there is no guaranty that such a star actually exists. Namely, of all
e luminosities and masses only certain combinations correspond to actual stars
u claimed that Milne reached this conclusion because he assumed the absorptio
ent to be constant throughout the star.

rmore, Landau claimed that this assumption was made for mathematical conven
thing to do with reality. Under this limiting assumption the radius of the star disap
e L, M, R relation. Moreover, any real absorption coefficient leads to a relation b
R and in this way be exempt from the criticism put forwards
t Eddington's mass-luminosity relation.

dau proposed to overcome this problem by 'methods of theoretical physics', a
ent reminiscent of Eddington's years ago logo. What Landau did was to derive t
on for the structure of the star (the equation of hydrostatics) from thermodynamic
siderations based on dynamics, which is the usual way. Assuming the cold (vanis
ature) gas to obey the Fermi-Dirac statistics and without mentioning whic
es of the gas that obey this statistics, Landau derived that the gas should a
y the equation used by Eddington for his gaseous stars (supported by radi
handrasekhar for his white dwarf (supported by a gas

d reached the conclusion that a mass larger than 1.5$M_\odot$ should colla
But, Landau noticed that: As in reality such masses exist quietly as s
t show any such ridiculous tendencies, we must conclude that all star
er than 1.5$M_\odot$ certainly posses regions in which the laws of quantum
anics are violated.

led Landau to assume such a far reaching conclusion? As Landau
ated: As we have no reason to believe that stars can be divided into
cally different classes according to the condition if the mass is greater
er than M_{crit}, we may suppose that all stars posses such pathological
s.

ospect, it is difficult to understand why the assumption of the violation
um theory by stars, which contradicts Landau's very first premise ab
theoretical physics, was easier to accept than the assumption that s
ave different courses of evolution depending on their mass, or was it
esentment from a collapse to a black hole? Should we apply Landau'
s quotation: Cosmologist are often wrong but never in doubt to this c

on of Chandrasekhar's or Stoner's discoveries of a critical mass whi not too long before. The only paper Landau mentioned was his own eierls.

1 Chandrasekhar extended his research in two directions: in a paper unicated by Milne, he expanded Milne's theory of collapsed objects pted to explain the structure of white dwarfs. At the end of this paper lrasekhar gave a table in which he separated between the fate of the stars and the high mass stars, just the point Landau rejected.

cember 1932 Russell gave the First Maiben Lecture before the American Associatio cement of Science the topic being: The Constitution of the Stars. He stated that: The have, within the last few years, changed their role from most perplexing to the best tood class of stars. The present theory of their nature (which we owe to Milne) is the notable triumph of the application of general physics to stellar constitution. All the were attributed to Milne and his colleagues at Oxford. The cambridgian Chandrase t even mentioned.

sary to emphasize one major result of the whole investigation, namely, tha
be taken as well established that the life history of a star of small mass mu
tially different from the life history of star of large mass. For a star of small
tural white dwarf stage is an initial step towards complete extinction. A sta
cannot pass into the white dwarf stage, and one is left speculating on othe
bilities.

rasekhar final paper on the limiting mass with the new and rigorous derivation of
mass for WDs came in 1935. First, Chandrasekhar removed any references to
on (symbolically, introducing the radiation was Eddington's main achievement).
he question: what happens to masses above the limiting mass? What Chandras
ed to state in the previous paper he dared to write this time: configurations of gre
must be composite (which means Milne's models) these composite configuration
ral limit ...zero radius. In a footnote Chandrasekhar added that: In the previous p
ndency of the radius to zero was formally avoided by introducing a state of 'maxi
y' for matter, but now we shall not introduce any such states, namely for the rea
rs from general considerations that when the central density is high enough for
d deviations from the known gas laws to occur, the configuration then would hav
adii that they would cease to have any practical importance in astrophysics. In o
Chandrasekhar did not believe at that time in the reality of what we call today bl

rasekhar[144] final paper on the limiting mass with the new and rigorous derivation of the limiting mass for WDs came in 1935. First, Chandrasekhar removed any references to
cing the radiation was Eddington's main achievement). Next, came the question: what happens to masses above the limiting mass? What Chandrasekhar hesitated to state i
o write this time: configurations of greater mass must be composite (which means Milne's models) these composite configurations have a natural limit ...zero radius. In a foot
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 s
ppears 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 s
cease to have any practical importance in astrophysics. In other words, Chandrasekhar did not believe at that time in the reality of what we call today black holes. Chandrasek
ears later[145].

Black Holes

9 (two months later) Einstein published an examp
(proof?) that no collapse to BH takes place.

Eddington published his last paper on the physics of white dwarfs where he repe
uments why the Stoner-Anderson formula was wrong. A formula established em
in conditions, claimed Eddington, is extended to conditions in which it has not be
by a procedure known as 'the principle of induction' or less euphemistically as
lation'. Such extrapolation, though often leading to progress, is fairly sure to bre
sooner or later . . . Eddington betrayed his own principles about the universal va
sical laws.

Do not be afraid of big names, they may be in error

Great names may make great errors

The truth eventualy comes out

ngton was an english quaker. Refused the draft dur
WWI. Never married.

ington did a lot to bring german science to englan
ught relativity to england at a time german science
o a large extent ignored in england or was at a fier
competition

Chandrasekhar was married never had children
handrasekhar descends from a noble indian family
who had several famous scientists