bellows. When the serrations are sufficiently marked, one layer after another in succession, beginning with the uppermost, separates itself from the lower part of the image, becomes narrower horizontally and much thinner vertically, turns green or blue, often at least at the pointed extremities first, and disappears. In the last two or three years I have repeatedly witnessed this phenomenon, obtaining all the way from two to six green and blue flashes. In the one case in which six colored flashes were certainly observed, the serrations were quite deep, the sun's disk was not very red, and all or nearly all the flashes were distinctly *blue*. The last layer at disappearance became whitish, as the upper edge of the image often does when the sun sets red. When the serrations are not deep and the layers are thin, the layers may shrink horizontally without becoming distinctly separated from the lower image, the pointed and colored ends moving inward slowly until the layer disappears.

In one very interesting case the sunset over the ocean red and oval (as usual becoming flatter beneath), but at first without noticeable serrations. As the sunset progressed the image became sharply divided by a horizontal line, ending in somewhat deep and sharp depressions. Below the line the image was distinctly and uniformly yellowish green, above the line uniformly reddish, or reddish yellow, the redder portion having an area perhaps three-quarters that of the whole image. As the sunset progressed further, the color again became homogeneous and red and the depressions disappeared, while the image took on the form of a rectangle capped by an isosceles triangle with somewhat rounded top. The top of the triangle now came off, turned blue, and disappeared. Then in between the point at which this disappearance occurred and the flattening disk another blue flash appeared, where nothing had been visible before. The image then became more and more flattened, and thinner vertically, without changing appreciably in horizontal width, and disappeared red (as the image often does).

Most of these observations were made with one inch achromatic binoculars magnifying about six diameters.

S. J. Barnett

University of California at Los Angeles and
California Institute of Technology,
May 31, 1934.

The Magnetic Moment of the Neutron

Our application[1] of the g-formula to the spin and orbit of a neutron in the nucleus is only partially correct, although the result (neutron $=-0.6$ magneton) is not affected. But the coordination of l and j in the tables is to be changed. The correct theory together with important generalizations is given meantime independently by I. Tamm and S. Altschuler.[2] They find the value -0.5 similar to ours. We do not agree with the analysis of H. Schueler[3] who gives the neutron -1.65 magnetons.

Alfred Landé
D. R. Inglis

Ohio State University,
June 7, 1934.

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[1] Inglis and Landé, Phys. Rev. **45**, 842 (1934).

[2] Tamm and Altschuler, Comptes Rendus de l'Acad. des Sciences de l'USSR **1**, 458 (1934).

[3] Schueler, Zeits. f. Physik **88**, 323 (1934).

Remarks on Super-Novae and Cosmic Rays

We have recently called attention to a remarkable type of giant novae.[1] As the subject of super-novae is probably very unfamiliar we give here a few more details which are not contained in our original articles.

1. Distribution of super-novae

In our calculations we made use of the assumption that on the average one super-nova appears in each galaxy every thousand years. This estimate is based on the occurrence of super-novae in the following galaxies,

Our own galaxy	in 1572
Andromeda	1885
Messier 101	1907

These three systems are located within a sphere of radius 12×10^5 light years.

In the Virgo cluster, which contains about 500 nebulae, six super-novae were found on plates taken during the last thirty years. As a curiosity we mention that in N.G.C. 4321, which is a member of Virgo, two super-novae have appeared in 1901 and 1914, respectively.

In the same interval of 30 years six additional super-novae were found in isolated nebulae.

We wish to emphasize that all of these finds are chance finds since a systematic search for super-novae has been organized only recently.

From the estimate of one super-nova per galaxy per thousand years it follows that 10^7 super-novae appear per year in the 10^{10} nebulae which are contained in a sphere of 2×10^9 years radius (critical distance derived from the red shift of nebulae). If cosmic rays come from super-novae their intensity in points far away from any individual super-nova will be essentially independent of time.

2. Comparison with the lifetime of stars

The lifetime of stars is supposed to be of the order of at least 10^{12} years. A nebula contains about 10^9 stars. These estimates, combined with the frequency of occurrence of one super-nova per galaxy per 10^3 years suggest that the super-nova process might occur to every star once in its lifetime, marking perhaps the cessation of its existence as an ordinary star. We realize that this suggestion is highly speculative in view of the possibility that the frequency of occurrence of super-novae may depend on time and in view

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[1] W. Baade and F. Zwicky, Proc. Nat. Acad. Sci. May, 1934.

of our complete ignorance with respect to the evolution of the universe.

3. *Ions in super-novae*

If super-novae are giant analogues to ordinary novae we may expect that ionized gas shells are expelled from them at great speeds. If this assumption is correct, part of the cosmic rays should consist of protons and heavier ions. Direct tests by cloud chamber experiments at high altitudes are desirable in order to test this conclusion. Also the problem suggests itself to investigate how much energy corpuscular particles lose on their long journey through space. On the picture of an expanding universe this loss has been computed by R. C. Tolman.

4. *Fluctuations of cosmic rays*

In our original papers we have calculated the change in intensity of cosmic rays caused by flare-ups of super-novae in nearby galaxies. The estimates given are perhaps too optimistic in view of the fact that the velocities of different particles are different. If various particles are ejected simultaneously at the time $t=0$ from a galaxy which is 10^6 L.Y. away the times t of arrival on the earth are

$t=10^6$ years for light if its velocity does not depend on the frequency.

$t_1=10^6$ years $+410$ seconds for 10^{11} volt electrons.
$t_2=$ " $+47.6$ days " 10^9 " "
$t_3=$ " $+44$ years " 10^{11} " protons.

These time lags t_i-t would tend to smear out the change of intensity caused by the flare-up of individual super-novae. Dr. R. M. Langer in one of our seminars was the first to call attention to the straggling of simultaneously ejected particles.

5. *The super-nova process*

We have tentatively suggested that the super-nova process represents the transition of an ordinary star into a neutron star. If neutrons are produced on the surface of an ordinary star they will "rain" down towards the center if we assume that the light pressure on neutrons is practically zero. This view explains the speed of the star's transformation into a neutron star. We are fully aware that our suggestion carries with it grave implications regarding the ordinary views about the constitution of stars and therefore will require further careful studies.

W. Baade
F. Zwicky

Mt. Wilson Observatory and
California Institute of Technology, Pasadena.
May 28, 1934.

Doubly-Excited States in Helium

The authors have been interested in the calculation of energy levels in doubly-excited helium with the purpose of verifying the identifications of far ultraviolet helium lines suggested by Kruger[1] and by Compton and Boyce,[2] and Rosenthal's[3] theory of the corona spectrum. Variational calculations of the states $(2s)(2p)^1P$ and $(2s)(2p)^3P$ (with the use of two-parameter trial functions as accurately orthogonal as possible to the functions of all the lower states) places $(2s)(2p)^1P$ at 296,118 cm^{-1} above $(1s)^+$ (the limit of single ionization) and $(2s)(2p)^3P$ at 274,526 cm^{-1} above this limit. We have found that the combinations $(1s)(2s)^3S-(2s)(2p)^3P$ and $(1s)(2p)^1P-(2s)(2p)^1P$ correspond with good accuracy to the lines 320.39A and 309.04A, respectively. The first transition gives a calculated wave-length 319.51A, agreeing with the experimental value to 3 parts in a thousand. The second gives 309.32A, agreeing with the experimental value to one part in a thousand.

The first transition is a perfectly good permitted transition and would be expected to appear prominently in the far ultraviolet spectrum. The error has the correct sign; that is, a more accurate calculation of the level, $(2s)(2p)^3P$ would place it slightly lower, thus increasing the corresponding wave-length and improving the agreement. We thus agree with Compton and Boyce, who suggested that this line is $(1s)(2s)-(2s)(2p)$ without specifying singlet or triplet and with Kruger only in the fact that we make it a triplet. (Kruger has $(1s)(2p)^3P-(2p)^2\,{}^3P$ for the 320 line.)

The assignment of $(1s)(2p)^1P-(2s)(2p)^1P$ for the 309 line we suggest tentatively simply because of the very good numerical agreement and are perfectly aware of the objections to it. In the first place the error has the wrong sign for a variational method which uses a trial function orthogonal to the lower state wave functions. Such a method should place the level higher than the true level. If this assignment is correct, our calculated level is lower than the correct level. This fact, however, is not serious, because one can never be sure of the orthogonality and may thus overshoot the mark. In the second place the transition violates the Laporte rule and would thus have to be attributed to quadrupole radiation or to electric field-perturbed dipole radiation. Compton and Boyce state that their light source was field-free and Kruger does not find the line.

A rough calculation of $(2s)^2\,{}^1S$ places this level at about 275,000 cm^{-1} above $(1s)^+$. $(1s)(2s)^1S-(2s)^2\,{}^1S$ thus becomes about 307,000 cm^{-1}. Kruger gives 279,715 cm^{-1} for the 357 line, which he attributes to $(1s)(2s)^1S-(2s)^2\,{}^1S$. Our calculation thus casts doubt upon this assignment.

Rosenthal[3] has suggested that the corona lines are due to jumps between levels of doubly-excited helium, corresponding to lines of the ordinary helium spectrum with the inner electron a $2s$ rather than a $1s$ electron. He selects the corona lines 5303.12, 3986.88 and 3600.97 as forming a series and attributes them to the transitions $(2s)(2p)^3P-(2s)(nd)^3D$, with $n=3$, 4, 5, respectively. Using a Hicks formula, he computes the series limit, obtaining for $(2s)(2p)^3P$ a figure which corresponds to 296,904 cm^{-1}

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[1] P. G. Kruger, Phys. Rev. **36**, 855 (1930).

[2] K. T. Compton and J. C. Boyce, J. Frank. Inst. **205**, 497 (1928).

[3] A. H. Rosenthal, Zeits. f. Astrophysik. **1**, 115 (1930).