electron temperature, leading in turn to a distortion of the relict radiation spectrum. The possibility of other astrophysical consequences is presently under study.

Let us stop to discuss briefly the history of the problem. It is well known that electrons and radiation with equal temperatures are in identical equilibrium with respect to all processes, particularly Compton scattering. Dreicer [1] wrote down a kinetic equation for the electrons and reduced it to the Fokker-Planck form. We were unable, however, to find a published solution for an arbitrary photon spectrum.

Knowing that the electron distribution is Maxwellian, we can determine the temperature from the condition that the derivative of the radiation energy density, calculated in accord with the Kompaneets formulas, must vanish.

In conclusion, we take the opportunity to thank R. A. Syunyaev for a discussion.

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ANTIANALOGS AND GAMMA DECAY OF ANALOG STATES

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When a proton is added to an even-even target nucleus, states with two isospin values may be produced:

$$\psi_{\nu;T_>,T_<} = \frac{1}{\sqrt{2T_0+1}}\phi_\nu(p)\,\psi_{0,T_0,T_0} + \sqrt{\frac{2T_0}{2T_0+1}}\phi_\nu(n)\psi_{0;T_0,T_{0-1}}, \tag{1}$$

$$\psi_{\nu;T_<,T_<} = \sqrt{\frac{2T_0}{2T_0+1}}\,\phi_\nu(p)\psi_{0;T_0,T_0} - \frac{1}{\sqrt{2T_0+1}}\phi_\nu(n)\psi_{0;T_0,T_{0-1}}, \tag{2}$$

where $\phi_\nu(p)$ and $\phi_\nu(n)$ are the wave functions of the proton and the neutron in the state ν; $\psi_{0;T_0,T_0}$ and $\psi_{0:T_0,T_0-1}$ are the wave functions of the ground state of the target and of its isobaric analog, $T_0 = (N - Z)/2$ is the isospin of the target, and $T = T_0 \pm 1/2$. The state (1) is the isobaric analog of the state

$$\psi_{\nu;T_>,T_>} = \phi_\nu(n)\,\psi_{0;T_0,T_0} \tag{3}$$

of a nucleus of the type of target plus neutron, and the state (2) is customarily called the antianalog [1].

It is usually assumed (cf., e.g., [2]) that the antianalog is distributed over a larger number of states, owing to the residual interaction. Indeed, the antianalog has the normal isospin of the given nucleus, and one might expect no hindrances whatever with respect to interactions that mix it with other states. However, the available data on the gamma decay of the analog states of nuclei of the sd shell [3] indicates that the mixing interaction in these nucei is weak for some reason. They show that in an appreciable number of the cases the

the main fraction of the γ decay of the analog state is an M1 transition to a preferred level having the same spin and parity as the analog. Some of these data, pertaining to $7/2^- \to 7/2^-$ M1 transitions, are listed in the table. With the exception of the last column, the data are taken from [4].

$7/2^- \to 7/2^-$ M1 transitions in sd-shell nuclei

Nucleus Nucleus	Isospins and energies (in MeV) of initial and final states	Fraction (%) of total number of gamma quanta	$B(M1)_{theor}$ (Weisskopf units)	$B(M1)_{exp}$ (Weisskopf units)	$\langle 1f_{z/2}\|V_1\|1f_{z/2}\rangle$
P^{31}	$3/2;\ 9.40 \to 1/2;\ 4.43$	88	2.24	0.5 (?)	51.36
Cl^{35}	$3/2;\ 7.55 \to 1/2;\ 3.16$	97	2.24	1.4 ± 0.3	51.22
Cl^{37}	$5/2;10.34 \to 3/2;\ 3.11$	80	1.62	1.7 ± 0.3	52.76

These data are intepreted in [3, 4] as as an M1 analog-antianalog transition. It is seen from the table that the calculated and experimental values of B(M1) are in reasonable agreement, with the exception of P^{31} where, as noted in [4], the causes of the discrepancy are unclear.

Another argument favoring this interpretation follows from an analysis of the energies of the isobaric splitting in these nuclei. According to the Lane model [5], the energy of the isobaric analog-antianalog splitting is

$$E_{\nu;T_>} - E_{\nu;T_<} = \frac{2T_0+1}{A}\langle\nu|V_1|\nu\rangle, \tag{4}$$

where $(V_1/A)\,T$ is the isobaric potential. The last column of the table lists the values of the matrix element $\langle 1f_{z/2}|V_1|1f_{z/2}\rangle$, calculated with the aid of (4) (in all three cases, $\nu = 1f_{7/2}$). We see that they coincide within 3%.

It is necessary to ascertain first whether the antianalogs are a unique feature of sd-shell nuclei or whether they exist in a wider range of nuclei. It is possible to use for this purpose the data on the proton-transfer reactions ((d, n), (He^3, d), etc.), in which states with two values of the isospin are excited. It is seen from (1) and (2) that the following relation holds between the reduced proton widths of the analog and antianalog

$$\gamma^2_{pT_<} = 2T_0\,\gamma^2_{pT_>} \tag{5}$$

(a similar relation holds also between the corresponding spectroscopic factors). This relation can be used to separate the antianalogs from a group of states excited at a fixed value of the orbital angular momentum ℓ_p of the captured proton.

We shall show now that a study of the analog-antianalog gamma transitions can serve as a source of unique information concerning the structure of nuclear states. We have assumed so far that the "parent" state (3) and the analog and antianalog corresponding to it are purely single-particle states. Actually any state of an odd nucleus is "dressed" with core excitations, and can be written in the form

$$\psi_{a,T_>,T_>} = \sum_{\nu i} C^a_{\nu i}\,\phi_\nu(n)\,\psi_{i,T_0,T_0}\,, \tag{6}$$

where $\psi_{i;T_0T_0}$ are the ψ-functions of the excited states of the core. Both the single-particle a-d the fundamental component take part in the gamma transition between such states. It is just this circumstance which leads to renormalization of the external fields for the quasi-particles compared with the corresponding quantities for the free nucleons [6]. We shall show that, accurate to terms of order $1/(N - Z)$, only the single-particle components of these states take part in the analog-antianalog gamma transition, i.e., within the same accuracy, the external fields are not renormalized. Indeed, the wave functions of the analog and of the antianalog of the state (6) are

$$\psi_{a,T_>T_<} = \sum_{\nu i} C^a_{\nu i}\left\{\frac{1}{\sqrt{2T_0+1}}\phi_\nu(p)\,\psi_{i;T_0T_0} + \sqrt{\frac{2T_0}{2T_0+1}}\,\phi_\nu(n)\,\psi_{i;T_0\,T_0-1}\right\}, \tag{7}$$

$$\psi_{\tilde{a},T_<T_<} = \sum_{\nu i} C^a_{\nu i}\left\{\sqrt{\frac{2T_0}{2T_0+1}}\,\phi_\nu(p)\psi_{i;T_0T_0} - \frac{1}{\sqrt{2T_0+1}}\phi_\nu(n)\,\psi_{i;T_0T_0-1}\right\}. \tag{8}$$

We note that relation (5) is valid also in this case, since the spectroscopic factors are measured at a fixed value of ℓ_p. The matrix element of a gamma transition of multipolarity λ (practical interest attaches to M1 and E2 transitions) between (7) and (8) is

$$\langle\tilde{a};T_<T_<|\hat{m}_{\lambda\mu}|a;T_>T_<\rangle = \frac{\sqrt{2T_0}}{2T_0+1}\{\sum_{i;\nu\nu'} C^{a*}_{\nu i}C^a_{\nu' i}\langle\nu|\hat{m}^p_{\lambda\mu} - \hat{m}^n_{\lambda\mu}|\nu'\rangle +$$
$$+\sum_{\nu;ii'} C^{a*}_{\nu i}C^a_{\nu i'}[\langle i;T_0T_0|\hat{m}_{\lambda\mu}|i';T_0T_0\rangle - \langle i;T_0T_0-1|\hat{m}_{\lambda\mu}|i';T_0T_0-1\rangle]\}. \tag{9}$$

Let us consider the second term in the right side of (9). The γ-transition operator is $\hat{m}_{\lambda\mu} = \hat{m}^0_{\lambda\mu} + \hat{m}^1_{\lambda\mu}$, where $\hat{m}^0_{\lambda\mu}$ and $\hat{m}^1_{\lambda\mu}$ are the isoscalar and isovector components. The matrix elements of $\hat{m}^0_{\lambda\mu}$ cancel out, since they do not depend on the isospin projection. The matrix elements of $\hat{m}^1_{\lambda\mu}$ are proportional to

$$C^{TT_z}_{TT_z;10} = T_z/\sqrt{T(T+1)}.$$

Therefore the entire square bracket is of the order of $[T_0(T_0 + 1)]^{-1} \sim (N - z)^{-1}$, since the values of T_z for the core states and the corresponding analogs differ by unity. Hence, taking into account the vector addition of the angular momenta, we obtain

$$\langle\tilde{a}j_a\mu_a;T_<|\hat{m}_{\lambda\mu}|aj_a\mu'_a;T_>\rangle = \frac{\sqrt{2T_0}}{2T_0+1}\,\frac{C^{j_a\mu_a}_{j_a\mu'_a;\lambda\mu}}{\sqrt{2j_a+1}}\times$$

$$\times\left\{\sum_{\nu\nu'} \rho^{a\lambda}_{\nu\nu'} \langle \nu i_\nu \| \hat{m}^p_\lambda - \hat{m}^n_\lambda \| \nu' i_{\nu'} \rangle + O\left(\frac{1}{N-z}\right)\right\}, \tag{10}$$

where

$$\rho^{a\lambda}_{\nu\nu'} = (2i_a + 1)\sum_i C^{a*}_{\nu i} C^a_{\nu' i} (-1)^{i_i+\lambda+i_a+i_\nu} \begin{Bmatrix} i_i & i_a & i_\nu \\ \lambda & i_{\nu'} & i_a \end{Bmatrix} . \tag{11}$$

Thus, by investigating the analog-antianalog gamma transitions, we can obtain information concerning the structure of the nuclear states. The value of such information may be no less than that of the corresponding information obtained from nuclear reactions, since the uncertainty connected with the assumptions concerning the mechanism of the reaction does not arise in this case.

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CONCERNING ONE METHOD OF STUDYING RESONANCES IN MESON PHOTOPRODUCTION

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Recent progress in the study of πN scattering has led to the discovery of a number of new baryon resonances in the 1.5 - 3 GeV region. Attempts to observe these "new" resonances in the photoproduction of mesons on nucleons have so far not led to great success. Most of the resoances have not been observed at all (for example, $P_{11}(1470)$, $S_{31}(1640)$, $W_{11}(1710)$ etc.) and there are only slight indications of the presence of the others. This situation is most probably due primarily to the small contribution made by these resonances to photoproduction compared with the nonresonant background, and to the insufficiency of the experimental data. On the other hand, there may exist selection rules that forbid or suppress the manifestation of these resonances in photoproduction (thus, for example, the $P_{11} \to \gamma p$ transition is forbidden in the quark model [1]). This circumstance makes searches for resonances in photoproduction particularly interesting. A complete multipole analysis that would reveal resonances, in analogy with the phase-shift analysis of πN scattering, is made difficult by the presence of almost double the number of parameters (compared with πN scattering at the same value of the angular momentum) describing the photoproduction. In addition, we are lacking at present many of the data needed for such an analysis. As to the separation of the resonances only by observing the weak "humps" in the cross section, it is easily seen that the presence of a "hump" is not necessarily connected with the characteristic behavior of the resonant part