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GAMMA TRANSITIONS IN SELF-CONJUGATE NUCLEI*

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In a recent paper, Morpurgo[1] has shown that the rule "$M1$ transition strengths between levels with the same T in self-conjugate nuclei are expected to be on the average weaker by a factor 100 than the average normal $M1$ transition strengths" may be expected to hold. This rule is shown by Morpurgo to follow directly from the general matrix element for $M1$ gamma transitions with the isotopic spin formalism included.

It is the purpose of this note to point out that the inhibition shown by Morpurgo for $M1$ transitions may be expected to hold for magnetic transitions in general. The matrix element for a gamma transition in a self-conjugate nucleus between a state with quantum numbers TJm and a state with quantum numbers $T'J'm'$ is[2]

$$\langle T'J'm' | T_L^M | TJm\rangle = \tfrac{1}{2}\langle J'm' | T_L^M(\text{neutron}) + (-1)^{T+T'} T_L^M(\text{proton}) | Jm\rangle, \quad (1)$$

where T_L^M is the electric or magnetic operator. Apart from small differences due to the effects of core motion, the magnetic operator for a transition of multipolarity L, $M_L^M = M_L^M$ (neutron) $+ (-1)^{T+T'} M_L^M$ (proton), is proportional to $\mu_n + (-1)^{T+T'}[\mu_p + G/(L+1)]$, where G is a model-dependent statistical factor[2] which arises from the contribution of the orbital angular momentum of the proton. We obtain an order of magnitude estimate of the inhibition of magnetic transitions with $\Delta T = 0$ relative to those with $\Delta T = 1$ (for which the normal transition strength is expected) in self-conjugate nuclei by taking the square of the ratio

$$\frac{\mu_n + \mu_p + G/(L+1)}{\mu_n - \mu_p - G/(L+1)} = \frac{0.88 + G/(L+1)}{4.70 - G/(L+1)}. \quad (2)$$

The statistical factor G has values between ~-10 and ~5 for most cases of practical interest and has a statistical mean near -1, which is its value for $|J'-J| = L$. The order of magnitude of the inhibition from Eq. (2) varies then from $\sim(0.38/-4.20)^2 = 0.8\times10^{-2}$ for $L=1$ to $\sim(0.88/-4.20)^2 = 3.5\times10^{-2}$ for L very large.

As pointed out by Morpurgo, the modified Weisskopf estimate implied above for magnetic transitions with $\Delta T = 0$ in self-conjugate nuclei is an average value and large fluctuations in its value should be expected.

It is interesting to note that if it is generally valid to take into account the collective contribution of the core to electric quadrupole or octupole transitions by endowing[3] the particle (whether neutron or proton) making the transition with an additional charge αe, then collective contributions in self-conjugate nuclei are expected to be negligible for transitions in which $\Delta T = 1$. This rule follows directly from Eq. (1): if the neutron is assumed to have a charge αe and the proton a charge $(1+\alpha)e$, then Q_L^M (neutron) $+ (-1)^{T+T'} Q_L^M$(proton), where Q_L^M is the electric operator of order L, is closely proportional to $\alpha e + (-1)^{T+T'}(1+\alpha)e$. Therefore, for $\Delta T = 1$, the matrix element for an electric quadrupole or octupole transition in a self-conjugate nucleus is proportional to e rather than to $(1+2\alpha)e$ as it is for $\Delta T = 0$, and the introduction of the effective charge αe produces no enhancement of the transition.

*Under contract with the Atomic Energy Commission.
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LARGE-AMPLITUDE HYDROMAGNETIC WAVES ABOVE THE IONOSPHERE

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It has been shown that the earth's dipole field is probably confined within a distance of six to ten earth radii.[1,2] The dipole field is terminated at about this distance due to the relative motion of the earth and the ionized coronal gas. Variations in the density or velocity of the coronal gas will generate hydromagnetic waves at the edge of the earth's dipole field which will be propagated downward and may be observed at the surface of the earth as fluctuations in the geomagnetic field.

Figure 1 shows the calculated hydromagnetic wave velocity vs altitude. Arguments for the ion density values used in the calculation of this

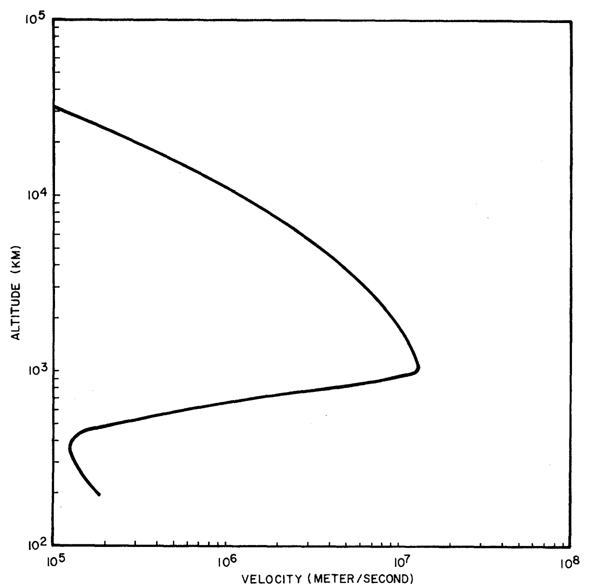

FIG. 1. Hydromagnetic wave velocity vs altitude above the surface of the earth. The hydromagnetic wave velocity in mks units is given by $v = B/\mu\rho^{\frac{1}{2}}$ where B = magnetic field strength and ρ = density of ions. This expression applies for both longitudinal and transverse hydromagnetic waves for the conditions existing above the ionospheric region. B at the surface of the earth is taken as 3×10^{-5} webers/meter^2 (0.3 gauss) for this graph.

curve are given in another paper.[3] It is to be noted that there are two regions where the wave velocity changes very rapidly with altitude: (1) at about 1000 km where the atmospheric density and, therefore, the ion density begin to increase exponentially downward; (2) below about 200 km where the ion density begins to decrease markedly downward. The decrease in ion density causes the wave velocity to rise to 3×10^8 meter/second below the 100-km level. Also, below about 200 km, the collision frequency between ion and neutral particles increases to the point where the hydromagnetic waves will be damped.

Thus, there are two regions (one near 1000 km and one below 200 km) where downward traveling hydromagnetic waves will be reflected or attenuated before they reach the earth's surface. Therefore, it may be concluded that hydromagnetic waves above the ionosphere have an amplitude greater than the geomagnetic fluctuations they produce at the surface of the earth. Crude estimates of the total effective transmission coefficient show that it is not unreasonable to expect hydromagnetic waves above the ionosphere to have an amplitude of the order of 10^2 times the amplitude of geomagnetic fluctuations observed at the earth's surface. This implies that on an average magnetically disturbed day, hydromagnetic waves with an amplitude of the order of 10^{-2} gauss are present between about 1000 km and six earth radii.

It is suggested that these large-amplitude hydromagnetic waves are responsible for producing the high-intensity particle radiation observed above about 1000 km by Van Allen et al.[4] Large-amplitude hydromagnetic waves will develop sharp crests which will enable them to accelerate particles effectively by the Fermi type acceleration process.[5] The relatively low radiation density below about 1000 km is explained in terms of the expected exponential increase in atmospheric density[6] below this level.

The ideas presented in this letter have been developed in much greater detail for a paper which is scheduled to appear in the September issue of the Journal of Geophysical Research.

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