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Fields on Plasma Ions by Collective Coordinates

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A discussion is given of the results of applying an improved method, employing collective coordinates, to the evaluation of the n-dimensional integrals occurring in the problem of determining the probability that a given electric field will appear on an ion in a plasma.

IN a previous paper,[1] the problem of obtaining the probability of a given electric field on an ion in a plasma has been discussed. Two methods employing collective coordinates were developed. They contain, however, the following three doubtful approximations. (1) The collective and particle coordinates are assumed to be independent although it is clear from Eq. (11) that they should be related. (2) The separation of the regions over which the integration is carried out using particle coordinates and using collective coordinates is not clean since the integration employing collective coordinates extends into the region of close approach of particles where only particle coordinates should be used. (3) The error in the approximation of the Jacobian of the transformation to collective coordinates given in Eq. (15) is not determined.

An improved method has been devised[2] that remedies these defects in the following ways. (1) When a particle's coordinates are used, they are not included in the collective coordinates. (2) Instead of supressing collective coordinates of high wave number by throwing away those with wave numbers greater than k_c, the interaction potential between pairs of particles $(1/r_{ij})$ is divided into long- and short-range parts at a separation distance equal to r_c and collective coordinates applied only to the long-range part. (3) The Jacobian of Eq. (15) is taken to be the first term of an expansion in Hermite polynomials and one of the higher order terms is computed as a guide to the range of validity of the use of the first term.

The following conclusions may be drawn from the improved method. (1) The value of r_c (corresponding to the former $\pi/2k_c$) should be chosen as small as possible without causing the higher terms in the expansion of the Jacobian to become appreciable. (2) The choice of r_c, corresponding to the value of k_c employed in reference 1, is such that the approximation to the Jacobian made there is good for values of θ greater than 0.6 but poor for smaller values. (3) The SRNN (short-range nearest neighbor) approximation reproduces rather well the values of $P(\epsilon)$ obtained from the improved method for θ's of 0.6 and above.

In the course of these calculations, an average short-range pair potential appears which is a function of temperature and directly related to the radial distribution function employed in Sec. II of reference 1.

[1] A. A. Broyles, Phys. Rev. **100**, 1181 (1955).
[2] A. A. Broyles, Atomic Energy Commission Report RM-1682 (unpublished). This report may be obtained by writing to the Rand Corporation, 1700 Main Street, Santa Monica, California.