On the constitutive assumptions for the recombination term for the R-D-D equations for scintillators

Fabrizio Daví
DICEA&ICRYS, Universitá Politecnica delle Marche, Ancona, (on leave at IMT-School for Advanced Studies, Lucca), Italy
E-mail: davi@univpm.it

Abstract: The evolution equations for inorganic scintillators (which converts ionizing radiations into visible light) were obtained in [1] (see also [2], [3]): they are Reaction-Diffusion-Drift equations, coupled with the Poisson equation of electrostatics and Neumann boundary conditions, in terms of the m-dimensional *charge carriers vector* $n \equiv (n_1, \ldots n_m)$:

$$\begin{aligned} \operatorname{div}(D[\nabla n] + MN[q \otimes \nabla\varphi]) + r(n) = \dot{n}\,, \\ -\epsilon\Delta\varphi = eq \cdot n\,, \end{aligned} \tag{1}$$

here D and M are the $m \times m$ *diffusivity* and *mobility* semi-positive definite matrices, $N(n) = \operatorname{diag}(n_1, \ldots n_m)$, φ is the *electric potential*, ϵ the *permittivity* of the crystal, e the elementary charge, $q \in \mathbb{Z}^m$ the *charge numbers vector* and finally $r(n)$ the recombination term which accounts for the visible photons production. Equation $(1)_1$ was obtained by the means of a microstructured continuum model, in the sense of [4], where the rate-of-change of the m- dimensional *director* is the *scintillation potential* $g(n) = eq\varphi(n) + F(n)$, where $F(n) > 0$ is a term of entropic nature.

Here we shall deal with various constitutive assumptions for the recombination term $r(n)$ and show how, when $F(n)$ is the Gibbs-Boltzmann entropy, we can recover the cubic polynomial expression used *e.g.* in one of the few previous existing phenomenological models [5]. Further we shall how a polynomial representation can be obtained as a limit of a Markov process and also explore the instance in which $F(n)$ is represented instead by the Fermi-Dirac potentials.

References

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