A Time-dependent Analysis of the Single-File Transport Model

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We follow up our contribution (1) about the 'one-ion' model describing ionic transport through biological membranes. Our work is now concerned with the time course of the well-known single-file movement (2) of ions through porous membranes. The essential assumptions for the single-file model are:

i) the pore is looked upon as a sequence of n binding sites, separated by energy barriers;
ii) the ions passing the membrane have to jump from one binding site to the other ('jump diffusion');
iii) each binding site contains no more than one ion;
iv) the pores (both, occupied or not) do not interact with each other.

Thus, the transport system may be described by a finite set of discrete variables which are assumed to be governed by a linear master equation with constant coefficients.

Results:
If the interactions of the ions being in a pore are taken into account, the oscillatory behaviour of the system will be determined by the 'one-ion' movement only. The oscillations which may exhibit, if the microscopic reversibility of the system is violated, will be always damped. It is shown, however, the more the ion flux is directed by an outer force and the more binding sites there are within a pore, the smaller the damping will become. It takes its minimum in the limit $n \to \infty$. In this case, even undamped oscillations might occur. Stable oscillations, however, may exhibit in our context, only if we drop the restriction iv) and replace it by a co-operative effect between the pores.

1. Stephan, W., Frehland, E: Annual Meeting of the Deutsche Gesellschaft für Biophysik (edited by G. Adam and G. Stark) 51 (1979).
2. Heckmann, K. (1972) Biomembranes 3, 127.