Data for Modeling of Positron Collisions and Transport in Gases

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Abstract. We review the current status of positron cross sections for collisions with atoms and molecules from the standpoint of modeling of positron transport in gases, vapours, liquids and human tissues. Recent results obtained by binary collision experiments, especially those based on measurements in a Penning- Malmberg-Surko trap, have been successful in producing the data with an accuracy that now matches that for electrons. The data include those for rare gases, some molecular gases (eg. N_2, H_2, CO_2, CF_4) and in particular the data for organic molecules and molecules relevant for applications in medicine (water, formic acid THF, pyrimidine). Based on the newly accumulated cross section data it has become possible to assemble the cross section sets necessary to model transport in gases, which are complete in terms of number, momentum and energy balance. However no single source is able to provide all the important data with equal accuracy. In such a case for electrons the completeness of the set is tested by comparing calculated and measured transport data, but for positrons the transport coefficients were rarely measured in the past. Thus we have only shown that the present stage in understanding of charged particle transport is sufficient to interpret old experiments and we advocate building of new experiments. We also analyze kinetic phenomena generated by the very large positronium (Ps) formation cross section which is associated with a process that is non-conservative (number changing). Studies of positron transport allow kinetic theorists an opportunity to analyze the largest observed effect of non-conservative collisions on transport. Finally we show how the data are used to model applications in medicine and, for that purpose, the analysis of collisions and tracks in the human body (consisting mainly of water) may be now performed on the basis of elementary binary processes. Some modifications have to be made for studies in liquids but it turns out that significant changes in the cross sections occur for liquids only below the threshold for Ps formation. In addition the accumulated data and complete sets allow us to model the gas-filled traps used in the experiments and optimize their thermalization and overall performance. New methods of cooling may also be explained based on the knowledge of the binary positron molecule data.