Positronenannihilation in Gitterdefekten in KCl

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Publication Date:
1973

Permanent Link:

https://doi.org/10.3929/ethz-a-000199297 →

Diss. Nr. 4970

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ABHANDLUNG

zur Erlangung
des Titels eines Doktors der Naturwissenschaften
der
EIDGENÖSSISCHEN TECHNISCHEN HOCHSCHULE
ZÜRICH

vogelegt von

DIERK HERLACH
dipl. Phys. ETH
geboren am 1. September 1944
deutscher Staatsangehöriger

Angenommen auf Antrag von
Prof. Dr. F. Heinrich, Referent
Prof. Dr. J. L. Olsen, Korreferent

Juris Druck + Verlag Zürich
1973

ABSTRACT

The angular correlation between annihilation quanta of positrons annihilating in pure and additively coloured potassium chloride single crystals has been maesured up to colour centre concentrations of 6.1×10^{18} cm^{-3}. A narrow component with 5.3 mrad FWHM has been found in the correlation curves of samples containing more than ~10^{17} F-centres/cm^3. It is demonstrated by several experiments that F- and M-centres are responsible for the occurrence of the narrow component. The shape and intensity of the latter can easily be calculated from the assumption that positrons are captured by F-centre electrons forming localized positronium-like states at the negative ion vacancies. Least squares fits of this model to the experimental data yield a localization length of 5.48 ± 0.05 Å and a capture cross section of order 10^{-15} cm^2. This strongly supports the hypothesis of positronium formation. - The enhancement of the narrow component due to magnetic mixing of the m = 0 eigenstates of singlet and triplet positronium has been maesured in external fields up to 25 kGauss with the field parallel and antiparallel to the polarization of the positrons, respectively. The observed effect confirms the existence of a positronium-like state and yields information about the probability density of the positron at the electron, $|\psi(0)|^2$, the pick-off annihilation rate, δ, and the degree of polarization of the positrons emitted by the ^{22}Na source, P. From a least squares calculation based on the above mentioned model we find $|\psi(0)|^2/|\psi(0)|^2_{vac.} = 0.56 \pm 0.24$, $\delta = (2.66 \pm 0.65) \times 10^9$ s^{-1}, and P = 0.17 ± 0.04. The disagreement of our values with those obtained from lifetime maesurements can be explained by the existence of a positronium-like state in uncoloured crystals, which has been confirmed by the observation of a narrow component in the angular correlation of an uncoloured sample in a magnetic field. This bound state has also been found to be localized, the localization length being ~8.5 Å.