IMPURITY-HOST FORCE CONSTANT CHANGE OF MÖSSBAUER Sn^{119} IMPURITY IN METALLIC HOSTS

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IN THE BELOVED MEMORY

OF

MY NIECES, SUNITA AND BABITA,

WHO COULD NOT LIVE TO SEE THE

WONDERS OF SCIENCE

There is nothing in this World so purifying
as knowledge

------ GITA, 4/38

A C K N O W L E D G E M E N T S

------ but thanks and thanks
and ever thanks

Twelfth Night
Act iii Sc.iii

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A B S T R A C T

The theoretical problem of lattice dynamics of impurities in various hosts has been proposed in the form of various simplified impurity lattice models by Visscher (1), Dawber and Elliott (2), Maradudin (3) and Lehman and DeWames (4) assuming nearest neighbour central forces. Though such a theoretical approach gives an indication of the direction and amount of the force constant change, yet the assumed approximations are questionable. A more practical and widely accepted analytical impurity model has been proposed by Mannheim (5) which provides a physically meaningful theoretical framework and a consistent method of analysis of Mössbauer lattice dynamics experiments in cubic metals. In the present work the effective impurity-host force constant ratios and frequency moments of Sn^{119} impurity in cubic metallic hosts of copper, palladium and gold have been estimated using Mannheim's theory from experimentally measured Mössbauer parameters.

In the first part of the work, calculations have been made for calculating force constant changes from Mössbauer parameters using Mannheim's formulae. These calculations yield the frequency moments and the changes of spring force constants from temperature variations of Mössbauer recoilfree fraction and second order Doppler shift of Sn^{119} impurities in hosts of various masses. Such calculations of impurity host systems are made on the basis of nearest neighbour central forces model assuming Debye spectrum by taking account of the relative

weightage of resonance and localized modes of vibration. The computed results are interpreted to discuss as to how the temperature variations, mass of the host and force constant change would affect Mössbauer parameters.

The second part contains experimental work and the results obtained therefrom. The experimental studies of Mössbauer impurity-host systems had been so far mostly confined to that of Fe^{57} Mössbauer impurity present in heavier hosts. Large inconsistencies, however, exist amongst various reported values of Fe-host force constant changes. In the present work, a systematic experimental work has been carried out for Sn^{119} impurity atom present in metallic host of lighter as well heavier atomic weights. The transmission Mössbauer spectra have been carried out for dilute Sn^{119} impurity in the metals of Cu, Ti, Cd, Pd and Au in the temperature range varying from low temperature to high temperature using Sn^{119} Mössbauer source in $CaSnO_3$ matrix. The weighted mean frequencies of impurity in these alloys have been estimated from the temperature variation of Mössbauer absorption area. The analysis of the experimental data yields the weighted average frequency moments of substitutional Sn^{119} impurity, the effective impurity-host force constant ratio and the frequency spectrum of Sn^{119} impurity in various metallic hosts.

The following new results are obtained from the present work:

1. The ratio of effective impurity-host to host-host spring force constant, for all f.c.c. host lattices under study, have been found to be less than one; the impurity host spring-force constant is thus getting reduced for light as well as heavy hosts under study.

2. No localised modes of vibrations are present in any of the impurity-host systems under study.

3. The frequency spectra of Sn^{119} impurity in various hosts indicate a resonance peak having maximum of the mean square amplitude at different frequencies for various hosts.

4. There is no systematic dependence of the impurity-host force constant change on any single host parameter that can be unambiguously correlated to the observed change in the effective force constant ratios. It is inferred that these changes may depend upon the combination of several host-parameters.

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