

less than 1. It turns out, therefore, that in the second case where $m < 0$, Vaidya's conclusion "the singularity is enclosed in a black hole" is not correct. The region of validity of the metric is thus given by rotating the shaded portions about Oz. It can be further shown that at large distances from the origin O the surfaces $\rho = 0$ and $\rho = \pm |\rho_0|$ tend to be parallel because of the fact that as $\gamma \rightarrow \infty$, $\theta \rightarrow \alpha$.

In a private communication Vaidya has agreed with the conclusions of the present author.

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STUDIES ON ELASTIC ANISOTROPY AND CAUCHY RELATION IN DOPED NaCl CRYSTALS*

THE elastic constants, anisotropy factor and degree of failure of Cauchy relation have been worked out for several alkali halides by many workers both theoretically and experimentally. The study of these parameters in doped crystals is however not reported in the literature. The results obtained in NaCl and doped NaCl crystals are presented in this note.

The experimental techniques for the measurement of ultrasonic velocities in sodium chloride as well as thallium, caesium and cadmium doped sodium chloride crystals has been reported¹ recently. The elastic constants, the elastic anisotropy factor and the degree of failure of Cauchy relation have been calculated for the above crystals and the results are presented in Tables I, II and III respectively.

The anisotropy of the alkali halides at room temperature has been studied by Reinitz². According to him the magnitude of the anisotropy is dependent largely on the size of the alkali ion. The small size of the lithium ion causes the anisotropy of lithium halides to become more than unity. The temperature dependence of the anisotropy has been studied by Nikanorov *et al.*³. They point out that for crystals of the NaCl type there is a sizable increase of the anisotropy factor with temperature. Lewis *et al.*⁴ also observed an increase in anisotropy factor in alkali halides as the temperature increases. Their results indicated that Li halides become more isotropic while the Na, K and Rb halides become less isotropic as the temperature decreases towards $T = 0^\circ \text{K}$. From Table II, we can see that the anisotropy factor for NaCl (NaCl crystal grown without adding intentionally any impurity) is very nearly equal to the

TABLE I
Elastic constants of NaCl and doped NaCl crystals

Crystal	C_{11}	C_{12} 10^{11} dynes per cm^2	C_{44}
NaCl	4.850 (4.870)*	1.334 (1.311)*	1.270 (1.266)*
NaCl (Cs)	4.666	0.058	1.845
NaCl (Tl)	4.648	0.666	1.509
NaCl (Cd)	4.811	0.697	1.495

* Lewis *et al.* (Reference 4).

TABLE II
The elastic anisotropy factor $A = 2C_{44}/C_{11} - C_{12}$
for NaCl and doped NaCl crystals

Crystal	Present work RT	Lewis <i>et al.</i> ⁴
NaCl	0.7224	0.677 at 300°K 0.577 at 4.2°K
NaCl (Cs)	0.8007	..
NaCl (Tl)	0.7578	..
NaCl (Cd)	0.7269	..

TABLE III
The degree of failure of the Cauchy relation
 $\Delta = C_{12} - C_{44}$ in units of 10^{11} dynes/ cm^2
for NaCl and doped NaCl crystals

Crystals	Present work RT	Lewis <i>et al.</i> ²
NaCl	0.084	0.045 at 300°K -0.208 at 4.2°K
NaCl (Cs)	-1.787	..
NaCl (Tl)	-0.843	..
NaCl (Cd)	-0.798	..

value given by Lewis *et al.*⁴ whereas for all the doped crystals the anisotropy increases. This increase in doped crystals may be due to the preferential precipitation of the impurities along $\langle 110 \rangle$ direction as reported earlier¹.

Lowdin⁵ using many body potential of central type and from quantum-mechanical calculation of cohesive energy and the elastic constants of a solid correctly predicted the failure of Cauchy relation ($C_{12} \neq C_{44}$ for real materials). More recently Dick⁶ introduced a modification of the Born-Mayer

model which includes many-body forces arising from a consideration of the overlap of the electronic shells of the ions and dealt primarily with the quantity $\Delta = C_{12} - C_{44}$ which expresses the degree of failure of the Cauchy relation. Lewis *et al.*⁴ observed that the Cauchy relation $C_{12} = C_{44}$ is not satisfied at 4.2° K for any of the alkali halides. The degree of failure of the Cauchy relation $\Delta = C_{12} - C_{44}$ is observed to increase with temperature. In fact they noticed that Δ actually changes sign from 300 to 4.2° K for several of the alkali halides. The Cauchy relation, which for a cubic system reduces to $C_{12} = C_{44}$ is predicted to be true only if the forces between the ions in a solid are of central, single body character, the ions are centres of inversion symmetry and the crystal is in an unstrained state. Since doping the crystal with impurities increases the internal strains in the crystal, Δ must increase. As can be seen from Table III, the absolute value of Δ is more in doped NaCl crystals compared to NaCl crystal. In fact Δ actually changes sign in doped crystals.

These observations show that the preferential precipitation of impurities along $\langle 110 \rangle$ direction causes increase in anisotropy, whereas the increase in internal strains is responsible for the increase in the degree of failure of Cauchy relation.

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SOME PLATINUM METAL COMPLEXES OF THIOSALICYLIC ACID

THIS communication describes the results of the studies in solution on the complexation reactions of thiosalicylic acid (TSA) with some platinum metal ions—Rh(III) and Pt(IV). Potentiometric and spectrophotometric studies on Rh(III)-TSA system reveal the formation of a complex of 1 : 2 :: M : L stoichiometry. Pt(IV)-TSA system has been studied spectrophotometrically and formation of a 1 : 3 :: M : L complex at pH 5.0 and another 1 : 1 :: M : L complex at pH 8.0 has been inferred. Stepwise stability constants and free energy of formation have been calculated wherever possible. Complexes of thiosalicylic acid with a number of other transition metal ions have been reported¹⁻⁸ earlier.

Thiosalicylic acid was an Evans Chemetics product of 99.9% purity. Fresh alcoholic solutions were prepared whenever needed. Rhodium chloride solutions were prepared by dissolving $RhCl_3$ in minimum hydrochloric acid and the Rh(III) content was estimated gravimetrically. Platinum(IV) solutions were prepared by dissolving H_2PtCl_6 in alcohol and the Pt(IV) content was estimated gravimetrically. All other chemicals used were of AnalaR grade and solutions were prepared in double distilled water. pH-measurements were made on a Leeds-Northrup pH meter supplied with all-purpose glass electrode operated by 220 volts mains. All measurements in Rh-TSA system were made in 40% alcoholic medium and the reaction mixtures were heated to 100° C and cooled for completion of the complexation reaction. In Pt-TSA system 50% alcoholic medium was used and the reaction mixtures were kept for 48 hours before measurements. Spectrophotometric measurements on Rh-TSA system were made on Unicam SP 500 spectrophotometer using 40% alcohol as blank. Metal as well as ligand show negligible absorbance under the experimental conditions. The pH metric titrations were carried out in an atmosphere of nitrogen and the ionic strength of the solutions was kept constant with perchloric acid and sodium perchlorate. Spectrophotometric measurements on Pt(IV)-TSA system were made on a Perkin-Elmer spectracord model 4000 A using the ligand solution as blank. Necessary corrections for the absorbance of metal ion under experimental conditions were made.

Rh-TSA system.—Rhodium(III) forms yellow coloured complex with thiosalicylic acid (on heating the reaction mixture). Spectrophotometric studies show that the complex has a pH-independent absorption maxima in the wavelength region 370-380 m μ . The formation of the complex has been