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The intrinsic luminescence of solid Ar, Kr and Xe [1] as well as of serveral alkali halides [2] established so far consists of broad, stokes shifted emission bands. These bands are explained by the radiative decay of a molecular luminescence center which is generated either by self trapping of an exciton or by self trapping of a hole and additional capture of an electron. Up to now, the radiative decay of free excitons in the above mentioned materials is controversal. Toyozawa [3] pointed out, that in alkali halides the free exciton state is unstable because of exciton-lattice interaction, whereas the self trapped exciton state is stable. In solid rare gases, however, besides the stable self trapped exciton state, a metastable free exciton state is expected to exist, both being separated by a potential barrier. Consequently, solid rare gases are expected to yield intrinsic luminescence from the metastable free exciton state as well as from the stable self trapped exciton state.

For solid Ar, Kr, and Xe, up to now only Hanus et al. [4] reported on both kinds of luminescence, whereas a variety of other experiments exclusively yielded the broad band luminescence (see, e.g. Ref. given in [1,4]). Because

Hanus et al. used an electron beam of high intensities for excitation purposes it was argued that the solid rare gases may be vaporized by the electron beam and that the very weak "free exciton emission lines" were due to emission of rare gas atoms (5).

Because the existence of "free exciton emission" in solid rare gases is of considerable interest with respect to Toyozawa's theory, we tried to establish the results of (4) for solid Xenon. For excitation purposes we used a commercial α source (Am^{241}, 50 μ C) thus avoiding the problem of vaporization. The α source was mounted on a He cryostat in an UHV sample chamber. Xe of a purity of at least 99.997 % was condensed onto the α source at different temperatures (5 K to 50 K). The thickness of the layers was about 100.000 Å. It was kept below the range of the α particles in solid Xe. This is an essential condition if luminescence occurs which is influenced by self absorption. The α source (1 mm x 10 mm) served as entrance slit of a Seya Namioka monochromator which analyzed the luminescence of the Xe layer. The luminescence light was converted by a sodium salicylate phosphor to the visible and detected by photon counting techniques. Because the luminescence intensity in the energetical region of free excitons was very weak, only a band pass around 40 Å could be used.

A typical result of our measurements is presented in Fig. 1. Besides the well known broad emission band around 1750 Å a very weak emission shows up around 1510 Å. The peak position of this band coincides with the sharp "free exciton emission" lines found by (4). The position of these lines is indicated by arrows. The width of the band found in our experiment is caused by the band pass of the monochromator.

The emission around 1510 Å is only detectable after annealing of the samples at 65 K to 70 K. Therefore the 1510 Å emission cannot be due to impurities

like Kr. An annealed sample yields the 1510 Å emission in the whole temperature range covered by our measurements (5 K to 60 K). For temperatures around 60 K, the 1510 Å emission is superimposed to the well known 1640 Å emission of solid Xe [6]. This is demonstrated in the insertion of Fig. 1.

The intensity ratio of the 1510 Å and 1750 Å emission is roughly 1/500. It reflects the ratio of the radiative lifetime of free excitons and the trapping time for the self trapping process. For the radiative lifetime of free excitons a value between some 10^{-9} sec and 10^{-8} sec is assumed. The latter value results from a model calculation of Toyozawa [7] based upon the polariton picture and hence taking into account self absorption of the free exciton emission. For the trapping time, a value between some 10^{-12} sec and 2×10^{-11} sec is deduced. The upper limit is fairly larger than the result of a calculation of Martin ([8], $\sim5\times10^{-12}$ sec).

The influence of annealing on the existence of the 1510 Å emission should be discussed in connection with the influence of annealing on the diffusion length of free excitons in Xe. The diffusion length seems to be much larger in annealed samples than in not annealed samples [9]. Perhaps the potential barrier separating the metastable and stable exciton state gets only effective when rather large crystallites are present and the energy of the free exciton is well defined. In small crystallites the energy fluctuations due to the influence of lattice defects may be larger than the height of the potential barrier.

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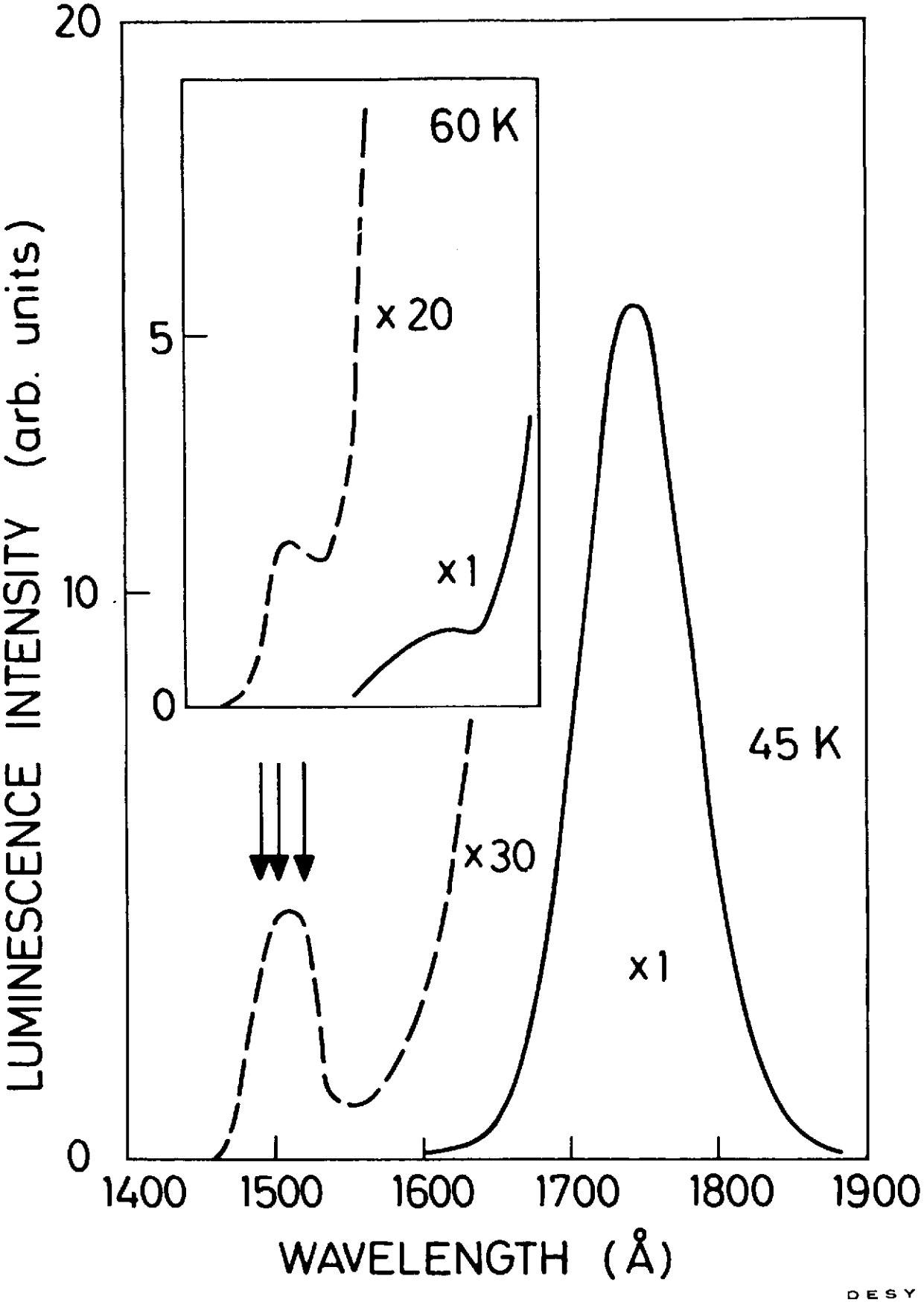
Figure Captions

Fig. 1 Intrinsic luminescence of solid Xe excited by α-particles, measured at 45 K and 60 K (insertion)


20
10
0
LUMINESCENCE INTENSITY (arb. units)
60 K
x 20
5
x1
0
45 K
x30
x1
1400
1500
1600
1700
1800
1900
WAVELENGTH (Å)

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