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EXCITON DROPLETS IN ZERO DIMENSIONAL SYSTEMS IN A MAGNETIC FIELD

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The emission spectrum of self-assembled InGaAs/GaAs quantum dots filled with up to 10 excitons is measured in magnetic fields up to 13 Tesla. The spectrum shows a number of peaks which split and rearrange with the magnetic field. The behaviour of the spectrum with carrier density and magnetic field is compared with detailed calculations. The model allows us to interpret our results in terms of coherent many-exciton states and their destruction by the magnetic field. The level structure of the spectra is related to the shell structure and collective excitations of many-exciton droplets in these artificial atoms. © 1997 Published by Elsevier Science Ltd. All rights reserved

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There is currently great interest in the creation [1–7] of dense exciton droplets in zero dimensional systems (0D). The most promising realization of 0D systems are the self-assembled quantum dots (SAD), small quasi-two-dimensional semiconductor structures with discrete density of states and electronic shells similar to atoms [8–11]. The ability to add/subtract individual excitons in 0D systems could open up a number of interesting possibilities, from exciton condensation in confined geometries, optical quantum logic gates [12], single-photonics [13], to quantum dot lasers [2]. In particular, an understanding of the operation of a QD laser requires the knowledge of the behaviour of many interacting electrons and holes. This knowledge is still missing as demonstrated by recent experiments [3–7]. For example, a "Fermi gas of excitons" has been invoked by Bockelmann *et al.* [3] to explain spectral features in the recombination spectrum of a finite density of electrons and holes. The high excitation spectra observed by Bayer *et al.* [4], Lipsanen *et al.* [5], Fafard *et al.* [6] and Raymond *et al.* [7] were identified with a simultaneous emission from ground and populated excited states in quantum dots but no apparent band gap renormalization was found. The lack of band gap renormalization was very puzzling in view of time resolved PL experiments [3, 7] which clearly showed that the observation of excited states was due primarily to a significant population of electrons and holes and not due to impeded thermalization of a single electron hole pair. Intriguing features were also observed in spectra of highly excited quantum wells in a strong magnetic field [14] where quantization of kinetic energy is provided by the magnetic field. The recent theoretical work [15–17] showed that the electronic shell structure and the interactions characteristic of particles in SAD are indeed responsible for nontrivial behaviour of this strongly interacting system. These shells of degenerate states are quite analogous to Landau levels and much work has been devoted to understanding unusual behaviour of excitons in strong magnetic fields [14, 18]. In SAD, strongly interacting electrons and valence holes in a

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