Representation of Quantum Entanglement using Thermo Field Dynamics

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In a quantum system, several states are entangled essentially through non-separable quantum fluctuations. A typical example of this physical phenomenon is seen in the singlet state. These behaviors of quantum states are called “quantum entanglements”. This quantum entanglement plays an important role of quantum computations, and it is useful in applications of ADS/CFT correspondence [1,2]. Furthermore, the entanglement entropy is used as a useful parameter in some quantum spin systems [3,4]. Recently, we have introduced a new method to understand the quantum entanglement by the thermo field dynamics (TFD) [5]. The TFD is described by a double Hilbert space including the original and tilde spaces. On this double Hilbert space, we introduce an extended density matrix, and we make a general formulation of the reduced density matrix in order to obtain the entanglement entropy. Some applications of this scheme to quantum spin systems will be discussed.