Pomeau, Yves; Tran, Minh-Binh Statistical physics of non equilibrium quantum phenomena. (English) Zbl 07160314 Lecture Notes in Physics 967. Cham: Springer (ISBN 978-3-030-34393-4/pbk; 978-3-030-34394-1/ebook). xv, 227 p. (2019).

These Lecture Notes on the Statistical Physics of Non Equilibrium quantum Phenomena present a very original exposition of quantum statistical concepts in application both to atomic radiative systems and to dilute quantum boson gas media. The book consists of two relatively separated parts, Statistical Physics of the Interaction of a Single Atom or Ion with Radiation and Statistical Physics of Dilute Bose Gases.

The first part deals with the emission of photons by a single atom, in particular, an interesting example of the fluorescence of a two-level atomic system is analyzed, having assumed that the related evolution is Markovian. This made it possible to model it by means of the Kolmogorov like equation, which takes into account the quantum jumps associated to the emission of photons in a statistical way. In the absence of spontaneous decay of the excited atomic levels by the random emission of photons, the atomic systems, presenting regular oscillations so-called Rabi oscillations, between the two atomic states, were successfully described by the Kolmogorov equation, whose solutions possess the information of the fluorescence light spectrum and the higher order time correlations.

It is worth to underline here that the authors' approach to studying the excited atomic systems, based on the probabilistic reasonings, is free of usual difficulties of other methods such as those based on analytical continuation of the energy spectrum, and demonstrates clearly fundamental physics backgrounds of the atomic processes.

For the readers convenience the authors supplied this Part of Lecture Notes with extended Summary, Conclusion, and Appendix, within which there are compactly combined main equations, details of techniques used for their solutions and the related fluorescence theory extension to the three-level quantum atomic systems.

The Second Part of the presented Lecture Notes deals namely with statistical physics of non-equilibrium quantum phenomena in dilute bosonic gases. The exposition of main theory backgrounds is based on quantum Boltzmann equations, following Balescu book [18, LN-citation]. It is well known that firstly a theory of dilute bosonic gases was developed by Bogolubov [28,LN] making use of the classical perturbation method, considering the interaction as small and computing the first order corrections, when the unperturbed state was taken within the Bose-Einstein condensate theory of perfect gases. Later this problem was studied by Lee and Yang [104,LN], who used the Hamiltonian diagonalizing canonical Bogolubov transformation for including the interaction between particles at finite momentum and the condensate. As it is mentioned by the Lecture Notes authors, they studied the related model with the Bogolubov spectrum and found a difference subject to the corresponding results obtained by Lee and Yang [loc. cit.].

A large enough presentation is devoted to studying quantum phase transitions in the context of the formation of condensates and the associated evolution of coherence leading to the establishment of off-diagonal long range order. Such models are based on a picture of excitations with a particle like spectrum at temperatures $T \geq 0.5T_{BE}$, whose modified equation takes into account the nonconservation of the bogolon number during collisions. It was shown the importance of the C31-collision operator between the excitations in addition to the $1 \rightleftharpoons 2$ and $2 \rightleftharpoons 2$ type collisions. Being first studied in detail in a paper by Peletminskii and Yatsenko [126,LN] traditional kinetic equations, these higher order excitations were studied by Gust and Reichl [77,78-LN] and developed by this Lecture Notes authors, who constructed a new model and tested by several experiments. In particular, they computed the speed and life-time of the first and second sound modes in mono-atomic BECs and found their agreement with many experimental data. This and related results, presenting the computation of the hydrodynamics modes and the experimental comparisons, are discussed in Chapter 8 in great details. Special section of the Lecture Notes is devoted to a well-posedness theory, within which there are presented strong statements about the unicity and existence of solutions to the equations derived in the work, as well as the suitably argued definitions of mass, momentum, energy notions and collision operators, entering the model description.

Summarizing the above account of topics discussed in the Lecture Notes, one needs to firmly state that they will serve as a good source of many important fundamental questions in modern quantum statistical physics and kinetic theory of dilute quantum bose gas systems, useful both for mathematical and theoretical physicists.