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Sommario: This thesis is composed of 143 pages and archived in PDF format The theory of statistical mechanics provides a powerful conceptual framework within which the relevant (macroscopic) features of systems at equilibrium can be described. As there is currently no equivalent capable of encompassing the much richer class of non-equilibrium phenomena, research in this direction proceeds mainly on an instance-by-instance basis. The aim of this Thesis is to describe in some detail three such attempts, which involve different dynamical aspects of classical and quantum systems. As summarised below, each of the last three Chapters of this document delves into one of these different topics, while Chapter 2 provides a brief introduction on the study of non-equilibrium dynamics. In Chapter 3 we investigate the purely relaxational dynamics of classical critical ferromagnetic systems in the proximity of surfaces, paying particular attention to the effects that the latter induce on the early stages of the evolution following an abrupt change in the temperature of the sample. When the latter ends close enough to the critical value which separates the paramagnetic from the ferromagnetic phase, it effectively introduces a temporal boundary which can be treated as if it were a surface. Within this picture, we highlight the emergence of novel effects near the effective edge formed by the intersection of the two spatial and temporal boundaries. Our findings are apparently in disagreement with previous predictions which were based on the

assumption that the presence of such an edge would not affect the scaling behaviour of observables; in order to explain this discrepancy, we propose an alternative for the original power-counting argument which, at least, correctly predicts the emergence of novel field-theoretical divergences in our one-loop calculations. We show that said singularities are associated with the scaling at the edge. Moreover, by encoding our findings in a boundary renormalisation group framework, we argue that the new predicted behaviour represents a universal feature associated to the short-distance expansion of the order parameter of the transition near the edge; we also calculate explicitly its anomalous dimension at the first-order in a dimensional expansion. As a qualitative feature, this anomalous dimension depends on the type of phase transition occurring at the surface. We exploit this fact in order to provide numerical support to our predictions via Monte Carlo simulations of the dynamical behaviour of a three-dimensional Ising model. The main results reported in Chap. 3 have appeared in Ref. [1]. In Chapter 4 we revisit the Euclidean mapping to imaginary times which has been recently proposed [2, 3] as an alternative for approaching the problem of quantum dynamics following a quench. This is expected to allow one to reformulate the original problem as a static one confined in a film geometry. We show that this interpretation actually holds only if the initial state of the dynamics is pure. Statistical mixtures, instead, intertwine the effects due to the two boundaries, which therefore cannot be regarded as being independent. We emphasize that, although the aforementioned reinterpretation as a confined static problem fails, one is still able, in principle, to write down and solve the corresponding equations. We also discuss in some detail the relation between this approach and the real-time field-theoretical one which makes use of the two-time Keldysh contour. For this purpose, we study the analytical structure of relevant observables â such as correlation functions â in the complex plane of times, identifying a subdivision of this domain into several sectors which depend on the ordering of the imaginary parts of the involved time coordinates. Within each of these subdomains, the analytic continuation to the real axis provides in principle a different result. This feature allows one to reconstruct from the Euclidean formalism all possible non-time-ordered functions, which in particular include all those which can be calculated via the Keldysh two-time formalism. Moreover, we give a prescription on how to retrieve response functions, discussing some simple examples and rationalising some recent numerical data obtained for one of these observables in a one-dimensional quantum Ising chain [4]. We also highlight the emergence of a light-cone effect fairly similar to the one previously found for correlation functions [2], which therefore provides further confirmation to the fact that information travels across the system in the form of the entanglement of quasi-particles produced by the quenching procedure. We have reported part of this analysis in Ref. [5]. Chapter 5 presents part of our recent work on effective relaxation in quantum systems following a quench and on the observed prethermalisation. We analyse the effects caused by the introduction of a long-range integrability-breaking interaction in the early stages of the dynamics of an otherwise integrable quantum spin chain following a quench in the magnetic field. By employing a suitable transformation, we redefine the theory in terms of a fully-connected model of hard-core bosons, which allows us to exploit the (generically) low density of excitations for rendering our model exactly solvable (in a numerical sense, i.e., by numerically diagonalising an exact matrix). We verify that, indeed, as long as the parameters of the quench are not too close to the critical point, the low-density approximation captures the dynamical features of the elementary operators, highlighting the appearance of marked plateaux in their dynamics, which we reinterpret as the emergence of a prethermal regime in the original model. As expected, the latter behaviour is reflected also on extensive observables which can be constructed as appropriate combinations of the mode populations. For these quantities, the typical approach to the quasi-stationary value is algebraic with exponent a ? 3, independently of the size of the system, the strength of the interaction and the amplitude of the magnetic field (as long as it is kept far from the critical point). The plateaux mentioned above last until a recurrence time â which can be approximately identified with tR ? N/2 for single modes and t?R ? N/4 for extensive quantities â after which quantum oscillations due to the finite size of the chain reappear. Our procedure allows us to shed some light over prethermal features without having to considerably limit the size of the system, which we can choose to be quite large, as we discuss in Ref. [6].

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