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PREFACE

# Unity in the Diversity

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**Abstract** The Superstripes 2008 conference has been focused on the discovery of the amplification of the superconducting critical temperature $T_c$ in a novel realization (iron pnictides) of metallic heterostructures at the atomic limit called superstripes. These are formed by superlattices of superconducting units (layers, or stripes, or wires, or spheres or balls) separated by an intercalated material. Superstripes show multiband high $T_c$ superconductivity driven by the shape resonance or Feshbach resonance in the interband pairing that occurs by tuning the chemical potential at an electronic topological transition where the Fermi surface topology of one of the bands changes its dimensionality. The maximum $T_c$ amplification is reached by tuning the chemical potential to “shape resonance” by changing: the charge density and/or the superlattice structural parameters.

**Keywords** Multiband superconductivity · Feshbach resonance · Shape resonance · Iron pnictides

The search for the quantum mechanism that allows a superconducting macroscopic quantum condensate to resist the decoherence effects of high temperature is a major topic in condensed matter, quantum computing and in the search for quantum mechanisms in the living cell. The series of conferences on stripes and high $T_c$ superconductivity have been focused on shedding light on the relationships between mesoscopic phase separation and high $T_c$ superconductivity. In fact, in all high $T_c$ superconducting materials the quantum condensate of fermions at high temperature occurs at the verge of a mesoscopic phase separation. The discovery of a new set of materials, iron pnictide superconductors, in the early months of 2008 [1–3] with quite different characters from the known high $T_c$ superconductors like cuprates (discovered in 1986) and diborides (discovered in 2001) has triggered a very large scientific activity in the field. The discovery of very particular features of these new materials, which are in common with the previous known materials, has provided a very exciting scientific activity with the hope to find unity in the diversity [4]. The key common features are:

(1) The structure of the iron pnictides superconductors is made of a superlattice of $[\mathrm{FeAs}]_\infty^{-Q+\delta}$ with $Q = 1$, layers intercalated by spacers (oxide layers like $[\mathrm{LnF}_y\mathrm{O}_{1-y}]_\infty^{+Q-\delta}$ or $[\mathrm{LnO}_{1-y}]_\infty^{+Q-\delta}$ in the “1111” family or metallic atomic layers $[(\mathrm{A}^{+2}_{1-x}\mathrm{B}^{+1}_x)_{1/2}]_\infty^{+Q-\delta}$ in the “122” family [5], and therefore they represent practical realizations of a heterostructure at the atomic limit (HsAL) that was described to be the essential material architecture for the emergence of high $T_c$ superconductivity [6].
(2) The undoped parent compound at low temperature shows a commensurate striped phase with itinerant quasi 1D magnetism that has been shown to be similar to the striped phase in cuprates at $1/8$ doping [7].
(3) A mesoscopic phase separation where the striped magnetic phase coexists with the superconducting phase is given by the atomic substitutions in the stoichiometric parent compounds. This point is in common with the mesoscopic phase separation in cuprate superconductors in the doping range between $1/8$ and $1/4$ [8, 9].
(4) The electronic structure of the normal phase and the superconducting phase shows clearly that these new materials are multiband and multigap high $T_c$ superconduc-

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tors like diborides where a particular pairing mechanism is active in common with anisotropic superconductors: the exchange like interband pairing [10].

Since the two last points, mesoscopic phase separation and multiband superconductivity, have been the major topics of the series of conferences "*Stripes and High* $T_c$ *Superconductivity*" that started in Rome in 1996, we have organized the International Conference on "FeAs High $T_c$ Superconducting Multilayers and Related Phenomena" (*Superstripes2008*) Italy, Rome, 9–13 December 2008.

The most important experimental results obtained this year on this topic have been presented at the Rome conference. The large number of the presented works and their high quality have enabled them to cover the key features of these new high $T_c$ superconductors. Moreover the new advances on material science, on the global phase diagram, on the role of lattice effects, of microstrain in the superlattice, of the external pressure, and on the symmetry of the superconducting condensate have been discussed.

The emerging scenario is a multiband superconductivity and a complex network of mixed boson and fermion statistics [11, 12] in the verge of multiscale nanoscale phase separation [13], in the proximity of an electronic magnetic crystal like a Wigner crystal [14].

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