EFFECTS OF PARAMETRIZATIONS AND NUMERICAL RECIPES IN SMOOTHED-PARTICLE HYDRODYNAMIC (CDSPH) ON FORMATION AND EVOLUTION ON DWARF GALAXIES AND MODERN ADVANCEMENTS AND TO A MULTI-PHASE CHEMO-DYNAMICAL TREATMENT AND ITS APPLICATION

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Galaxies are gravitationally bound systems comprising stars and gas. In the present-day understanding of cosmological structure formation, galaxies start from low-mass Dark Matter halos which assemble gas that forms stars and merge hierarchically to larger aggregates like our Milky Way galaxy. The evolution of galaxies is, by this, determined by mass growth through accretion of environmental matter, the matter cycle through gas and stars, and with the release of element-enriched stellar matter. In addition, stellar energy release drives the dynamics of the interstellar medium in galaxies. Because observational developments by larger and multi-wavelengths air-borne and ground-based telescopes and advanced detector techniques allow to observe the universe in look-back time and, thereby, galaxies morphologies at various ages, numerical models should provide an insight to the physical processes at work and deepen the understanding of galaxy evolution. Simultaneously, with the advancements of observational tools the developments of computer facilities allow refinements of numerical codes to higher complexity.
Nonetheless, still computational limits exist that make the parameterization of physical processes on small spatial and time scales necessary and lead to simplifications in the treatment of gas physics. This herewith presented and already advancing project is based on an already existing fruitful collaboration between the two research groups from the Department of Astrophysics of Vienna University and from the Kavli Institute of Astronomy and Astrophysics (KIAA) at Peking University and was already supported over the last years by the OeAD from the Austrian side and by the Silkroad project of the Chinese Academy of Sciences (CAS) and by the KIAA. The project aims at developing a highly sophisticated 3D chemo-dynamical SPH code, named cdSPH, that allows to model galaxy evolution taking the natural multi-phase properties of the interstellar gas into account as well as the dynamics and chemistry of stars and the interaction processes between the galactic components, including star formation, stellar energetic and chemical feedback, heating and cooling processes of the gas phases. The models are compared with observations of galaxies at different evolutionary states.
Since present-day simulations of galaxy evolution mostly apply a single-phase description of the gas and treat physical gas-star interaction processes, like e.g. the formation of stars and their feedback to the gas, in a rough manner, our projects aims at two distinct but not independent objectives:

1. Comparison of different star-formation recipes and feedback parameterizations in numerical schemes and 2. to advance the gas description according to its existence as interstellar medium (ISM) in galaxies. Our numerical algorithm contains the internationally most advanced treatment of the multi-component nature of galaxies and their interaction processes and is, therefore, ideally suited to model the evolution of galaxies of different types. Because low-mass galaxies are particularly sensible to energetic effects from internal sources, as e.g. stellar radiation and explosions, and external influences, like e.g. tidal forces, this program application is aimed at studying numerical recipes and at modeling different types of dwarf galaxies: isolated dwarf galaxies, dwarf galaxies in cluster environment, satellite galaxies, and tidal-tail dwarf galaxies. Their chemical evolution can be traced from observations of stellar and gas dynamics and their chemical abundances. The joint project consists of four major parts:

1. Studying the effects of different star-formation and stellar feedback recipes on the evolution of isolated dwarf galaxies;
2. Comparison of the chemo-dynamical multi-phase galaxy models with recipes in single-phase SPH algorithms;
3. Comparison of isolated dwarf galaxy models with those approaching the galaxy cluster environment and its intergalactic hot gas (ICM) and, by this, experiencing the ram pressure of this ICM;
4. Since the advancement in galaxy modeling not only depends on the development of computer capacity and performance, also the proper adaptation of the numerical code to new processor architecture, here to GPU architecture coupled with updated versions of CUDA, must be in the focus of this project.The Viennese research group possesses a long-term experience in the chemo-dynamical treatment of galaxy evolution (started by Gerhard Hensler in 1987 at the University of Munich, continued at the University of Kiel and since 2003 at Vienna University) and detailed studies of the effects of sub-grid physical processes contributing to the chemo-dynamical prescription, like e.g. time-dependent radiative cooling, the energy deposit by radiation and wind-driven regions around massive stars, gas infall, heat conduction, and further more.
5. In parallel two numerical hydrodynamical concepts are followed, the description in a Eulerian grid and the Lagrangian particle treatment. The researchers of the Vienna University have developed the socalled chemo-dynamical prescription and perform its implementation into the two numerical architectures. In our joint project we intend to model the evolution of dwarf galaxies with the advanced cdSPH code in various environments, explore the effects of free parameters prescribing sub-grid physics, and further advance the code to higher precision of the representation of gas dynamics and energetic as well as the stellar component. In addition, the numerical performance should be enhanced by acceleration of the code on highperformance computing architectures like GPUs.