SECTION B - TECHNICAL PROPOSAL

Title of the project	**COMPUTATIONAL METHODS IN ASTROPHYSICS AND SPACE SCIENCES**
Acronym	**COMASS**
Executive summary	*(max. 2 page, Calibri 11)* This CDI Project is proposed by a research group representing a consortium of universities specialized in fundamental research and space science: West University of Timisoara (UVT), University of Craiova (UCV) and “Babes-Bolyai” University of Cluj-Napoca (UBB). The research theme stands on previous cooperation of the three groups, the last one being in the frame of a previous STAR Project (2013 – 2016) with the title “COMISIS - Computational methods in the Scientific Investigation of Space”. The new project extends the research area on complementary topics to those considered in the previous project. The accent is put now on gravitation and on the recent discovered gravitational waves. The study of spatial dynamics will be extended this time to the dynamics of cosmic objects. Both cosmic radiation and cosmic matter (including satellites and rockets) will be considered. Finally, the studies on the solar plasma will focus now on the specific aspect of the Kelvin-Helmholtz instability in the solar partially ionized plasma. The research program is organized in three main Work Packeges (WPs), each one coordinated by one of the institutions. There are nice synergies among the three groups. For example, reserchers from Partner 1 (UCV) are dealing both with analitical and computational models in Gravitation (WP 1) and with solar plasma and wind plasma approached in WP 3. The expected impact of the project can be defined in terms of research reports and of scientific papers published in ISI Journals. Three research reports and 10 scientific papers will be ellaborated during the 18 months of the project. Moreover, software technologies related to numerical cosmology and to estimation of the dynamics of spatial objects (spacecraft and satellites) will be implemented and validated. This will bring the project to a technology readiness level TRL 4. Let us point out the main expected contributions. The first research direction of the project reffers to the implementation of IT libraries devoted to numerical, symbolic computation and algebraic programming methods in space science areas. Analitic and numerical results will be obtained and compared with those already known on numerical relativity and detection of gravitational waves, astrophysical measurements on space probes, detection of different types of radiation and on other applications. We will study (using new computer routines) the possible effects of modified gravity on different processes as light deflection or free fall of particles around massive objects as black-holes or clusters of stars or gravitational waves generation in astrophysical processes. On the other hand we will study of velocity dependence of the greybody factors for fermions emitted as Hawking radiation by a Schwarzschild-de Sitter black hole. Properties of the scattered radiation on black holes will be also studied. Measurable effects in astrophysical experiments included in space missions will be pointed out.

	The second direction of the project is dedicated to the research in the field of spatial dynamics, more precisely on turbulences and nonlinear phenomena which can appear in the motion of spatial objects (planets and satellites). The research will extend the previous results obtained by the team from University of Craiova in COMISIS and will bring new original contributions related to the development of new mathematical tools for investigating spatial nonlinear phenomena and to the design of new reduced-order multiple observers with applications to the flight of spacecraft. Important models arising from Gravitation can be analyzed following the specific procedure of nonlinear dynamics, the Ricci flow equation being a good example. Also, the research will focus on phenomena related to the motion of spatial objects and to the propagation of cosmic radiations; we shall concentrate our attention to the Lie group method. Because during the flight of spacecraft or satellites, their constrained and turbulent dynamics is characterized by different disturbances, the estimation of the states and/or unknown inputs is an important challenge; to reduce the number of sensors and measurements systems, we will design reduced-order multiple observers for Takagi-Sugeno nonlinear systems to estimate some of the dynamics' variables using intelligent algorithms and software. Beside the new architectures to be obtained, the software package is another expected impact of the project, in terms of specific delivrables. On the third research direction, the relevance of Kelvin-Helmholtz instability (KHI) in the solar partially ionized plasma structures will be considered. The main expected impacts of the research will be related to a theoretical tool to predict the occurrence of unstable Kelvin-Helmholtz instabilities (dissipative instabilities or negative energy waves) in solar plasma with lower flow rates, as well as to the bulk transport properties of plasma through a statistical approach based on solving the stochastic differential equations. The existence of solar structures with partially ionized plasmas suggests the possibility to modify the criterion for the appearance of the KHI, allowing the onset of the instability. The existence of parameters whose values can be estimated only by statistically methods led us to propose an analytical and numerical method by which the classical two-fluid MHD formalism is modified by inserting stochastic analysis in determining the unstable solutions. The main goal is to obtain an equivalent instability condition containing parameters which may be compared to observations. As we already mentioned, the research approach of COMASS will assume objectives which start from TRL 1 and end to TRL 4.