JUpiter ICy moons Explorer (JUICE): AN ESA L-CLASS MISSION CANDIDATE TO THE JUPITER SYSTEM. M.K. Dougherty[1], O. Grasset[2], C. Erd[3], D. Titov[3], E. Bunce[4], A. Coustenis[5], M. Blanc[6], A. Coates[7], P. Drossart[5], L. Fletcher[8], H. Hussmann[9], R. Jaumann[9], N. Krupp[10], O. Prieto-Ballesteros[11], P. Tortora[12], F. Tosi[13], and T. Van Hoolst[14]. [1]Imperial College, UK, m.dougherty@imperial.ac.uk; [2]Nantes univ., France; [3] ESA/ESTEC, Netherlands; [4]Leicester univ., UK; [5]Paris-Meudon observatory, France; [6]Ec. Polytechnique, France; [7]Univ. College London, UK; [8]Oxford Univ., UK; [9]D.L.R., Germany; [10]M.P.I., Germany; [11]INTA-CSIC, Spain; [12]Univ. of Bologna, Italy; [13]Inst. For Interplanet. Space Phys., Italy; [14]Roy. Obs. of Belgium, Belgium.

Introduction: The discovery of four large moons orbiting around Jupiter by Galileo Galilei four hundred years ago spurred the Copernican Revolution and forever changed our view of the Solar System and universe. Today, Jupiter is seen as the archetype for giant planets in our Solar System as well as for the numerous giant planets known to orbit other stars. In many respects, and in all their complexities, Jupiter and its diverse satellites form a mini-Solar System. By investigating this system, and thereby unravelling the history of its evolution, from initial formation of the planet to the development of its satellite system, we will gain a general understanding of how gas giant planets and their satellite systems form and evolve and of how our Solar System works.

JUICE science goals: The overarching theme for JUICE is: The emergence of habitable worlds around gas giants. Humankind wonders whether the origin of life is unique to the Earth or if it occurs elsewhere in our Solar System or beyond. To answer this question, even though the mechanisms by which life originated on Earth are not yet clearly understood, one can assume that the necessary conditions involve the simultaneous presence of organic compounds, trace elements, water, energy sources and a relative stability of the environment over time. JUICE will address the question: Are there current habitats elsewhere in the Solar System with the necessary conditions (water, biological essential elements, energy and stability) to sustain life? The spatial extent and evolution of habitable zones within the Solar System are critical elements in the development and sustainment of life, as well as in addressing the question of whether life developed on Earth alone or whether it was developed in other Solar System environments and was then imported to Earth. The focus of JUICE is to characterise the conditions that may have led to the emergence of habitable environments among the Jovian icy satellites, with special emphasis on the three ocean-bearing worlds, Ganymede, Europa, and Callisto (Figure 1).

Ganymede is identified for detailed investigation since it provides a natural laboratory for analysis of the nature, evolution and potential habitability of icy worlds in general, but also because of the role it plays within the system of Galilean satellites, and its unique magnetic and plasma interactions with the surrounding Jovian environment. For Europa, where two targeted flybys are planned, the focus will be on the chemistry essential to life, including organic molecules, and on understanding the formation of surface features and the composition of the non water-ice material, leading to the identification and characterisation of candidate sites for future in situ exploration. Furthermore, JUICE will provide the first subsurface observations of this icy moon, including the first determination of the minimal thickness of the icy crust over the most recently active regions.

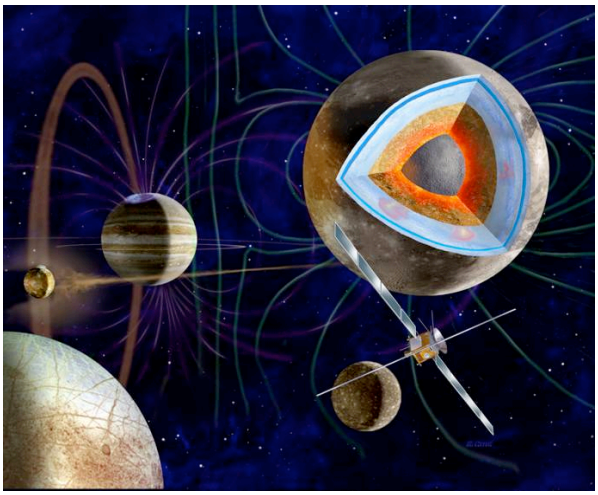

Figure 1: The JUICE spacecraft exploring the Jupiter system (Artist's view, Credit: M. Carroll)

JUICE will determine the characteristics of liquid-water oceans below the icy surfaces of the moons. This will lead to an understanding of the possible sources and cycling of chemical and thermal energy, allow investigation of the evolution and chemical composition of the surfaces and of the subsurface oceans, and enable an evaluation of the processes that have affected the satellites and their environments through time. The study of the diversity of the satellite system will be enhanced with additional information gathered remotely on Io and smaller moons. The mission will also focus on characterising the diversity of processes in the Jupiter system which may be required in order to provide a stable environment at Ganymede, Europa and Callisto on geologic time scales, including gravita-

tional coupling between the Galilean satellites and their long term tidal influence on the system as a whole.

Focused studies of Jupiter's atmosphere, and magnetosphere and their interaction with the Galilean satellites will further enhance our understanding of the evolution and dynamics of the Jovian system. The circulation, meteorology, chemistry and structure of Jupiter will be studied from the cloud tops to the thermosphere. These observations will be attained over a sufficiently long temporal baseline with broad latitudinal coverage to investigate evolving weather systems and the mechanisms of transporting energy, momentum and material between the different layers. The focus in Jupiter's magnetosphere will include an investigation of the three dimensional properties of the magnetodisc and in-depth study of the coupling processes within the magnetosphere, ionosphere and thermosphere. Aurora and radio emissions and their response to the solar wind will be elucidated.

The entire list of goals and objectives of JUICE are summarised in the table below.

JUICE mission scenario. On arrival in the Jupiter system following orbit insertion, JUICE will perform a tour of the Jupiter system using gravity assists of the Galilean satellites to shape its trajectory. This tour will include continuous monitoring of Jupiter's magnetosphere and atmosphere, two targeted Europa flybys, a Callisto flyby phase reaching Jupiter latitudes of 30°, culminating with the dedicated Ganymede orbital phase. The current end of mission scenario involves spacecraft impact on Ganymede. The spacecraft would be an orbital flight system using conventional bi-propellant propulsion systems. New technologies are not required to execute the current mission concept. Planned to be launched in 2022, JUICE would use chemical propulsion and an Earth-Venus-Earth-Earth gravity assist to arrive at Jupiter 8 years later. JUICE's trajectory will remain outside of the inner radiation belts at Jupiter and it uses solar arrays for its power source.

International co-operation JUICE is an ESA-led mission arising from the reformulation of the EJSM-Laplace mission, which was an ESA-NASA project. This has been carried out in consultation with the international science community and has broad appeal and strong support from planetary scientists.

Goals	Science objectives	
Exploration of the habitable zone: Ganymede, Europa, and Callisto	**Characterise Ganymede as a planetary object and possible habitat**	Characterise the extent of the ocean and its relation to the deeper interior
		Characterise the ice shell
		Determine global composition, distribution and evolution of surface materials
		Understand the formation of surface features and search for past and present activity
		Characterise the local environment and its interaction with the jovian magnetosphere
	Explore Europa's recently active zones	Determine the composition of the non-ice material, especially as related to habitability
		Look for liquid water under the most active sites
		Study the recently active processes
	Study Callisto as a remnant of the early jovian system	Characterise the outer shells, including the ocean
		Determine the composition of the non-ice material
		Study the past activity
Explore the Jupiter system as an archetype for gas giants	**Characterise the Jovian atmosphere**	Characterise the atmospheric dynamics and circulation
		Characterise the atmospheric composition and chemistry
		Characterise the atmospheric vertical structure
	Explore the Jovian magnetosphere	Characterise the magnetosphere as a fast magnetic rotator
		Characterise the magnetosphere as a giant accelerator
		Understand the moons as sources and sinks of magnetospheric plasma
	Study the Jovian satellite and ring systems	Study Io's activity and surface composition
		Study the main characteristics of rings and small satellites

Science goals and objectives of JUICE