Multipoint Observation of Europa Plumes Using FemtoSat Swarms

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The search for life beyond Earth remains a high-priority for the US Space Program. Since the start of the space program in 1957, we have learned events in outer space have been instrumental in seeding and evolving life on Earth. Meteorites which are the remains of asteroids have been shown to contain biochemicals including amino acids, the building blocks of life. Rare earth organisms are known to live in the upper atmosphere, and some are known to withstand the vacuum of space. The evidence suggest life is able to survive under very harsh conditions. Jovian moon Europa is known to have more water that all the Earth's oceans combined. Europa is hypothesized to have a liquid-water ocean containing enough nutrients and warm temperatures to sustain life. Yet the surroundings of Europa are extreme, due to the high-radiation created from Jupiter's magnetic field and low-temperatures, being far from the Sun. Yet Europa's ocean is protected with a thick layer of ice thought to be several kilometers thick. There is currently no feasible technique to break through the Europa ice layer and get into the ocean. Instead we can rely on plumes which are hypothesized to be outbursts of water from cracks in the ice sheet. Sampling these plumes could give us insight into the composition of the water and further collect evidence for life to exist or not in the ocean underneath. The main objective of this research is to develop new technologies and mission concepts to rapidly measure the plumes for evidence of life. The plumes of Europa are rare and thought to spread over a wide zone reaching altitudes of several hundred kilometers. There is a need for multipoint measurements of the plume to look for trace evidence of life. For this purpose, we propose the design and deployment of FemtoSat swarms that are equipped with spectroscopic LEDs to look for biological metabolism pathways. The mission concept is divided into three parts: modeling Europa's plumes, study the different trajectories that the FemtoSats could follow to study the plume (basically orbit design) and finally advanced design of the FemtoSats to search for life. For the plume modeling a statistical model for size, number and speed of particles is recreated. When designing the orbits of the FemtoSat it has to be accounted for the instability of high inclination orbits and fuel limitations. Finally, the main instrument of the FemtoSats would be a LED-based spectrometer that can detect life.