Boundary Conditions for Abiogenesis: Constraints on the UV Environment Relevant to Prebiotic Chemistry on Primitive Planetary Bodies

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Abstract: Recent laboratory studies (e.g., Ritson et al 2012, Patel et al 2015) suggest UV light may have played a critical role in the synthesis of molecules relevant to abiogenesis (prebiotic chemistry), such as RNA. UV light interacts with prebiotic chemistry in ways that are sensitive to wavelength and fluence level (e.g., Ranjan & Sasselov 2016a). Here, we use radiative transfer models to constrain the UV environment on Earth in the era of abiogenesis (~3.9 Ga). We exhaustively explore the available surface fluence as a function of surface conditions and atmospheric composition, exploring all plausible areas of parameter space. We convolve the resultant spectra against action spectra for prebiotically relevant processes to estimate the effect of these variables on prebiotic chemistry. Some workers have also suggested the possibility of abiogenesis on Mars and subsequent panspermic transfer to Earth (e.g., Benner+2015). Therefore, we also explore plausible UV spectral fluences on Mars at 3.9 Ga to evaluate its hospitality for prebiotic chemistry (Ranjan, Wordsworth & Sasselov 2016). Lastly, we calculate the UV fluences on exoplanets orbiting M-dwarfs, and evaluate the implications for the hospitability of these worlds for abiogenesis events. Our results represent one of the few boundary conditions available on prebiotic chemistry, and can also inform more general studies of photochemistry in the deep Archaean (e.g. SMIF).