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# Determining Habitable Zones in Binary Star Systems

S. Eggl (1), N. Georgakarakos (2), E. Pilat-Lohinger (3), and B. Funk (3)
(1) IMCCE Observatoire de Paris, F-75014 Paris, France (siegfried.eggl@imcce.fr), (2) Higher Technological Educational Institute of Serres, Terma Magnesias, Serres 62124, Greece, (3) Institute for Astrophysics, University of Vienna, A-1180 Vienna, Austria

## Abstract

Planets in and around binary star systems are subject to potentially large variations in insolation, especially when the planetary orbits become eccentric (Forgan, 2012; Kane & Hinkel, 2013). Eggl et al. (2012) were able to show that even planets on initially circular orbits experience large insolation variations due to the gravitational interaction between the two stars and the planet. It is, thus, not an easy task to identify Habitable Zones in such systems. We present an analytic framework suited to determine Habitable Zones in and around binary star systems using effective insolation values provided by Kopparapu et al. (2013). Accounting for the complex dynamical interaction between the planet and the binary star, we could define our Habitable Zones in such a way that they still remain independent of time up to stellar evolution timescales. Thus, our method provides a simple means of guiding observations to regions of interest, where terrestrial planets can remain habitable in double star systems.

## 1. Introduction

The discovery of a terrestrial planet in the $\alpha$ Centauri system (Dumusque et al., 2012) has boosted the scientific communities' interest in determining regions in and around binary star systems which may harbor terrestrial planets that support liquid water on their surfaces. Given the strong gravitational perturbations planets experience in such environments, significant variations in the planets orbit can be expected. The corresponding variability of planetary insolation has to be accounted for, if predictions on Habitable Zones (HZs) are to be attempted. In order to provide useful guidelines for observations, however, time dependent definitions of HZs should be avoided.

## 2. Methodology

Combining analytic results from perturbation theory with updated effective radiation values by Kopparapu et al. (2013), we were able to construct a framework for HZs in binary star systems that is independent of time up to stellar evolution timescales, but still contains all the information on the variability of the planetary insolation.

## 3. Results

We present a simple analytic method to calculate HZs for both, circumstellar (S-Type) and circumbinary (P-Type) systems. The application of our methodology to nearby binary stars indicates, that a large percentage of the investigated systems allows for habitable worlds (Eggl et al., 2013).

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