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Haze layer from reflection spectra of Titan-like exoplanets

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Abstract

Most of the studies about detection of exoplanetary atmospheres concern tangential transmission at the limb of the planets. This corresponding to the geometry of primary transit observations. However, the reflection planet spectra contains useful and specific information that would complete observation of primary transit. In this work we perform a study to determine in which extent we can obtain information about the haze layer of an atmosphere which is basically unknown. To perform tests, we use the atmosphere of Titan, which is a quite simple case with a spectrum dominated by haze and methane only.

1. Retrieval with a Titan-like planet

In a first part of the work, we study the relationhip, at very high resolution and in a narrow wavelength interval (each absorption line must be resolved), between a synthetic spectrum of intensity, the depth of the haze column that is probed and the outgoing intensity. To do so we use an atmosphere description relevant for Titan, then with a specific vertical profile of haze and of methane. The atmosphere is essentially composed of nitrogen, without spectral features, and bounded at 1.44 bar by a solid surface. For the methane, with use methane lines computed from ab-initio calculation

With this work, we show that the amount of haze probe at a given wavelength could approximatively be described by the outgoing intensity. If we connect the altitude where the integrated gas opacity reach 1 (defining a depth level) and the intensity profile, we can produce a vertical profile that is a good proxy of the haze vertical profile. The advantage is that we do not need to know the properties of the scatterers. The drawback is that this profile is proportional to the real opacity, but is not normalized. It can be used to quickly assess the existence of a haze.

2. Retrieval with an unknown planet

In a second step, we evaluated what kind of information could be retrieved from an atmosphere for which we know almost nothing. In this second step, we use synthetic spectra as in the first step, but we now ignore most of the information about the planet. The only informations which are supposed to be known are the average temperature of the atmosphere, the gravity, the size of the planet (to assume that we correctly know the geometric albedo) and the existence of gaseous methane.

We built a database of methane adsorption as a function of the wavelength and temperature and started to retrieve the haze properties, from intensity spectra, using the restricted information we have. We made tests with synthetic spectra, at wavelengths between 1 and 2.5 μm, at different spectral resolution and with a real spectrum of VIMS.

We find that we are able to retrieve a valuable vertical profile of the haze proxy, we are able to retrieve the spectral behaviour of the haze and as well a degraded information about the temperature profile. On the other hand, the existence of a surface is not unambigous defined and could be confused with a global deck of cloud.

3. Retrieval with an unknown planet

The next steps for this work will consist in ***1)*** implementing other gases to define if we can detect and define a more complex composition ***2)*** improve the retrieval of the haze layer with a better description of the gas vertical opacity ***3)*** Use other test planet and define if we can detect horizontal in-homogeneity in non-resolved planets.