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Excitation-energy resolved fluorescence spectra of hydrogen molecules in the regime of singly excited molecular states

Philipp Schmidt*, Andreas Hans*, Christian Ozga*, Philipp Reiß*, Ltaief Ben Ltaief*, Kouichi Hosaka*, Masashi Kitajima†, Noriyuki Kouchi†, André Knie*, and Arno Ehresmann*¹

* Institut für Physik and CINSaT, Universität Kassel, Heinrich-Plett-Straße 40, 34132 Kassel, Germany

† Department of Chemistry, Tokyo Institute of Technology, Meguro-ku, Tokyo 152, Japan

Synopsis We have measured the emission spectrum of gaseous hydrogen molecules in the far ultraviolet spectral range over the large interval of excitation energies between 11 eV and 17 eV. This regime is governed by singly excited electronic states below the ionization threshold. While these features have been already investigated separately in the past, the completeness of the present measurements allows a very intuitive representation of the participating molecular effects and their respective correlations. It also contains the first complete investigation of the Condon diffraction bands visible for hydrogen through transitions into the ground state continuum.

The hydrogen molecule is the most abundant molecule in the universe and has always been one of the most fundamental prototype systems in the field of molecular physics and spectroscopy in general. Precise knowledge of its characteristics is essential to most astrophysical observations and calculations [1].

At the same time, even the regime of singly excited states of this diatomic molecule is still a field of active work due to its complicated crossing of a variety of individual states [2,3,4]. By applying the method of photon-induced fluorescence spectroscopy (PIFS), where dispersed fluorescence is measured as a function of photon energy upon excitation by monochromatized synchrotron radiation, over a large interval of excitation energies, we were able to provide a complete compilation of the emission features in this regime. These include molecular fluorescence with vibrational progressions, predissociation resonances through various coupled electronic states as well as continuous emissions into the continuum of the X ground state. While these effects are already known individually, this kind of overview allows a much deeper understanding of their respective relations. It is also the first complete investigation of those continuum emissions and their intensity oscillations known as Condon diffraction bands [5, 6]. The comparison of the present data to readily available and ever improving theoretical data allows a concise evaluation of the corresponding theoretical methods.

In the future the present experimental technique can be used to deliver benchmark data for potential energy landscape calculations for species where such theoretical data is not available

from first principles. Due to the excitation state selective nature of the method, it can separate the individual features already with only modest resolving power.

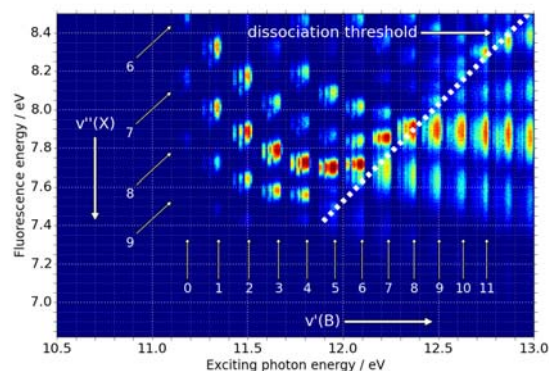


Figure 1. Part of the excitation-energy resolved fluorescence spectra showing vibrational progressions from the B state of hydrogen to the ground state (Lyman bands) from various upper and lower vibrational levels as well as continuum emissions beyond the dissociation threshold.

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¹ E-mail: Ehresmann@physik.uni-kassel.de

