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Measuring the Volatile Residue of Hydrocarbons in ET: the CRDS UHV System at the CIRCE Laboratories

A significant challenging feature of the ET vacuum system is the requirement on the hydrocarbon partial pressure (p_{hy}) for molecules heavier than 100 atomic mass unit (amu), as explained in the ET design report
\begin{equation}
p_{hy}\le1\cdot10^{-14}\,mbar
\end{equation}
In order to reach such an ambitious result, both the non volatile and volatile residue of hydrocarbons should be taken into account. In particular, the latter can introduce a non negligible contribution to the partial pressure in the vacuum system.
Nowadays, it is quite complex to provide an accurate measurement of the hydrocarbon partial pressure in Ultra High Vacuum (UHV) conditions. The typical approach involves a Residual Gas Analyzer (RGA), for which it is not simple to distinguish the contribution of different molecules in the spectrum provided by this instrument. Indeed, the RGA analysis requires a deep knowledge of the typical cracking fragments of the molecules that complicates the identification of many partial pressures in a vacuum system.
This work reports on the status of the new facility in UHV at the CIRCE laboratories [1], that has been designed to perform accurate measurements of p_{hy} using the extremely high-sensitivity technique known as Cavity Ring-Down Spectroscopy (CRDS) [2].
The technique is based on the measurement of the decay time of the transmitted intensity, once the incident radiation is instantaneously switched off. Such a time constant (known as cavity ring-down time) allows to determine the intracavity absorption coefficient, from which the absorbing gas concentration and partial pressure can be retrieved [2].
The system marks the first application of CRDS in UHV conditions, aiming to perform direct and accurate measurements of the distinctive cracking fragments of ultra light hydrocarbons ($<$ 100 amu) in order to remove the mass degeneracy in the RGA analysis of heavier hydrocarbons.
The present work aims to promote the CRDS in UHV, which is rather promising in measuring p_{hy} at the stringent levels required for ET, especially in the perspective to use it in the chain of processes for the UHV cleaning test, complementing the established Fourier-Transform Infrared spectroscopy (FTIR) and X-ray Photoelectron Spectroscopy (XPS) techniques.

[1] E. Tofani, S. Gravina, V. D'Agostino, E. Fasci, A. Grado, and L. Gianfrani, "Volatile Residue of hydrocarbons in ET: a UHV chamber for CRDS at the CIRCE laboratories", ET Docs ET-0163A-24 (2024)

[2] L. Gianfrani, S.-M. Hu, W. Ubachs,"Advances in cavity-enhanced methods for high precision molecular spectroscopy and test of fundamental physics.", La Rivista del Nuovo Cimento 47, 229–298 (2024)

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