A novel high repetition rate HHG source for the study of time-resolved electronic and magnetic structure of strongly correlated systems

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A very useful approach in understanding the interplay between charge, spin and orbital degrees of freedom in strongly correlated systems, as in the case of transition metal oxides, consists in investigating the timescale of the relaxation of the electronic properties after an optical perturbation. However, the principal tool for studying the electronic properties of a material, that is photoemission in all its branches, is difficult to be applied to time-resolved experiment, due to the features of commonly available pulsed sources: infrared or visible light lasers have photon energies too low with respect to the work function of solid samples, whereas Free Electron Lasers (FELs) have too high pulse intensity and too low repetition rate, so that either dramatic space charge effects are produced or a very low electron count rate is achieved.

We present here results from an experimental set-up recently commissioned at NFFA and T-Rex Lab in Trieste, termed SPRINT-lab (Spin Polarized Research Instrument in the Nanoscale and Time domain). The system, based on a High-Harmonic-Generation (HHG) \cite{1}, is able to produce high intensity harmonics up to the 27\textsuperscript{th} order of the 2.4 eV fundamental, with tunable repetition rate from single pulse up to 200 KHz. The end station is equipped with a 200 mm-radius hemispherical analyser for angular resolved photoemission and a vectorial Mott detector for the measurement of secondary electron spin polarization in both static and pump-probe method.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure1.png}
\caption{Energy-distributed curve of a polycrystalline gold film, acquired with 16.8 eV HHG source. Fit of the Fermi edge is showed in blue dotted line, performed deconvolving the Fermi-Dirac function with T = 40 K from a Gaussian accounting for the instrumental broadening.}
\end{figure}

With this set-up, an experiment of spin polarization is been planned on a manganite (La\textsubscript{x}Ca\textsubscript{1-x}MnO\textsubscript{3}), which at certain doping level has demonstrated to have an hidden metallic phase accessible by photo-excitation, a result discovered measuring in terahertz conductivity \cite{2} and confirmed by our recent measurements of satellite peaks in core level photoemission.

\begin{table}[h]
\centering
\begin{tabular}{|c|c|}
\hline
hv & 16.8 eV (HHG 7\textsuperscript{th} harmonic) \\
200 kHz & 22.4 µJ/pulse \\
Analyser resolution & 7.5 meV \\
\hline
\end{tabular}
\caption{Parameters of the HHG source used in the experiment.}
\end{table}