ATTOSECOND XUV LASER SOURCE FOR LCLS SCIENCE

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Introduction

The objective of this project is to design an XUV Laser setup which is modular and easily implemented on a variety of experiments as well as a possible future XUV Laser set up with full integration into an existing hutch.

Applications

- Spectroscopy of Molecules
  - For example; N2, O2, CO2
- Coherent Diffractive Imaging
  - A type of lensless imaging
- Time-resolved Electron Dynamics
  - Used for viewing charge distribution of a molecule or atom

Criteria

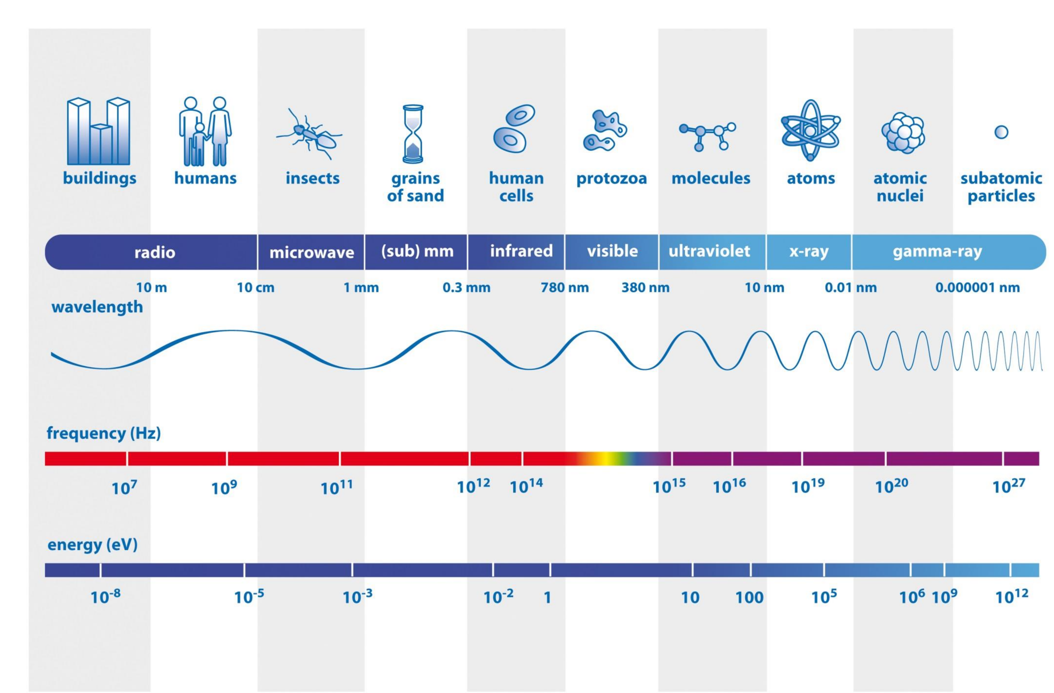
- An intensity of 1E8-1E9 photon per pulse
- The target harmonics are the 7th-15th odd harmonics of 800 nm
- A pulse duration of a few femtoseconds to a few sub femtoseconds

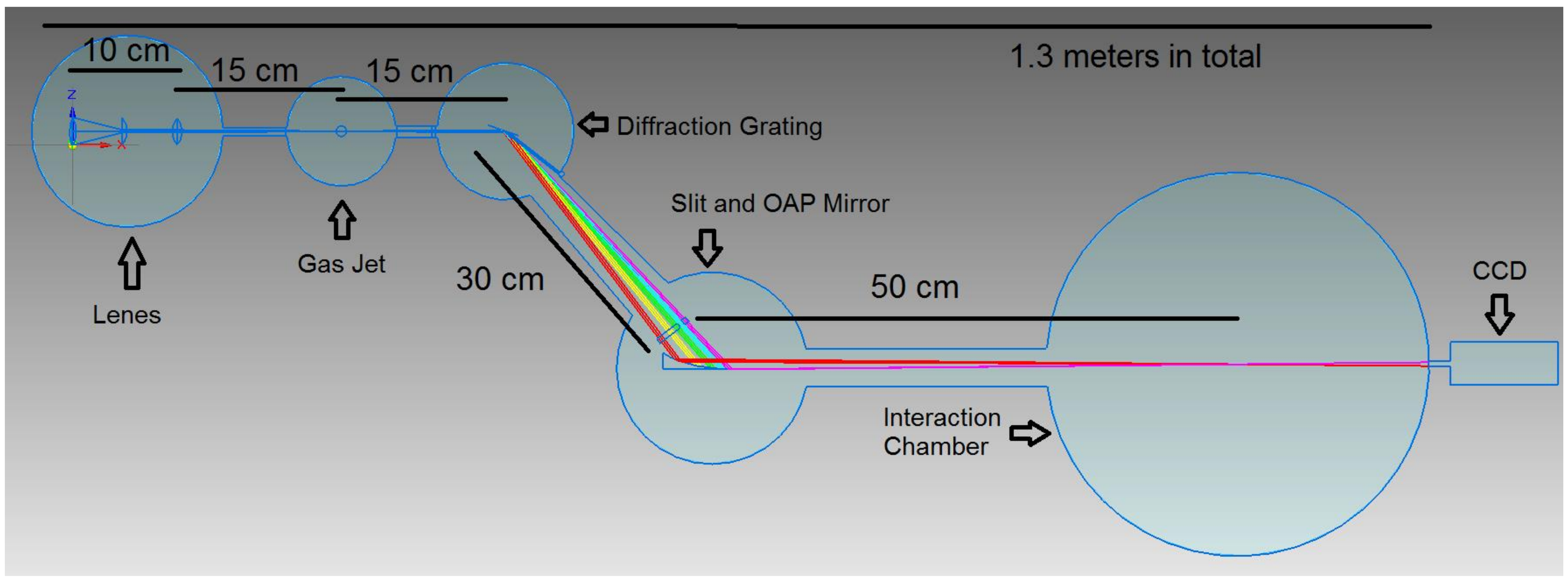
Challenges

- Efficiency
  - Solution: reduce the amount of interaction points
- Interfacing with existing experiments
  - Solutions: reduce the size of the chamber and make it easy to implement

The Electromagnetic Spectrum

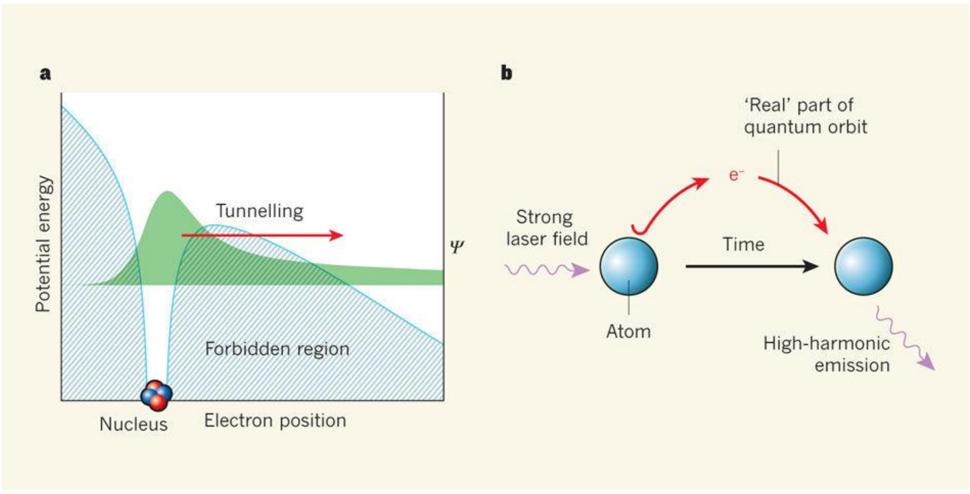
- At SLAC most wavelengths are producible
- Missing wavelengths from roughly 10nm to 125nm
- XUV is the missing part of the spectrum
  - The XUV range theoretically produced would be from 114 nm to 53 nm
- This would cover most of the missing spectrum





High Harmonic Generation

- HHG works by exciting gas molecules which excite an electron and causes tunneling ionization
- Once the electron is in its excited state it drops back down to its resting state and emits a photon
- The wavelength of the photon is determined by the gas and the energy from the light source.
- HHG can be enhanced and this design allows for changes to the generation process which could produce greater intensity as a result



Design

- Chamber 1: Lenses
  - 3 lenses are used to focus the beam and reduce the light then refocus it to the generation point.
- Chamber 2: Generation
  - High Harmonic Generation creates the XUV beam. A removable aluminum filter is used to filter out the remaining 800 nm light.
- Chamber 3: Diffraction
  - A diffraction grating is used to separate the harmonics.
- Chamber 4: Selection
  - A movable slit is used to select the desired harmonic. Then an Off Axis Parabolic mirror is used to focus the beam to the final chamber.
- Chamber 5: Interaction
  - The beam interacts with a sample or ends on a CCD

Conclusions

The design I proposed here allows for a relatively small form factor while still having sufficient photons per pulse. It also allows for upgrades to the generation chamber to increase the photons per pulse for future experiments. This phase of design is complete as well as getting quotes and selecting specific parts. The next step is to find the funds and have an engineer design the specifics of the chambers and vacuum system. Followed by finding or fabricating the more specialized parts like the chambers and the off axis parabolic mirror. After all the parts have been designed and acquired all that is left is to assemble and aligned the laser.

Citations

Lein, Manfred. “Atomic Physics: Electrons Get Real.” *Nature News*, Nature Publishing Group, 16 May 2012.

“UV Spectrum.” *Stanford Solar Center*, Stanford SOLAR Center, 2015.

Acknowledgments

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