PrismSPECT Benchmark Calculation:
Aluminum Ka Satellite Absorption Spectroscopy

In this benchmark calculation, we compare an aluminum K_α absorption spectrum computed using *PrismSPECT* with that obtained in a well-controlled, laser-produced plasma experiment. The experiment is described in Perry *et al*. (Phys. Rev. Lett. **67**, 3784, 1991). In it, an Al foil was heated to a measured temperature of 58 ± 4 eV, and it expanded to a measured density of 0.020 ± 0.007 g/cm^3. The Al was reported to be spatially uniform and in nearly complete local thermodynamic equilibrium (LTE). The spectral resolution in the experiment was 0.6 eV (or $\lambda/\Delta\lambda \sim 2500$).

K_α satellite absorption spectroscopy is an often-used technique for diagnosing conditions in laboratory plasmas. The spectrum arises from transitions of the type:

$$1s^2\, 2s^m\, 2p^n \rightarrow 1s^1\, 2s^m\, 2p^{n+1},$$

where n and m are integers. When n and m are both zero, the transition corresponds to the He_α transition ($1s^2 \rightarrow 1s^1\, 2p^1$). As n and m increase, the wavelengths of the satellite lines increase due to a decrease in the binding energy. Thus, the wavelengths of successively lower ionization stages are bunched together at successively longer wavelengths, and appear as satellites on the long-wavelength side of the He_α line.

<u>PrismSPECT Simulation setup:</u>

- Plasma Elements:
  - Add aluminum to the elements list.
  - For the atomic model, select *Backlighter K-Shell Spectroscopy*. This atomic model includes (autoionizing) energy levels with K-shell vacancies.
- Simulation Type:
  - For Atomic Rate Equations Solution, select: Steady-state.
  - For Plasma Variables, select: Planar, Maxwellian (1-T), Mass Density, and $\rho\, \Delta L$.
  - For External Radiation Source, select: None.
- Plasma Properties:
  - Set Plasma Temperature to 58 eV.
  - Set Mass Density to 0.02 g/cm^3.
  - Set Density*Thickness to 1.35e-5 g/cm^2 ($\Rightarrow$ an equivalent solid-density thickness of 500 Å)
- Atomic Processes:
  - Select LTE
- Spectral Grid:
  - Select a range from 1400 eV to 2000 eV, and 100 continuum points.
  - No backlighter is needed, as the transmission spectrum [defined by $\exp(-t_\nu)$, where t_ν = optical depth at frequency *n*] does not require using a backlighter in the simulation.

Simulation Results

Figure 1 shows a screenshot from the *PrismSPECT* spectral viewer. The spectrum in the display is the Transmission vs. Wavelength, and it is convolved with an instrumental spectral resolution of $\lambda/\Delta\lambda$ = 2500.

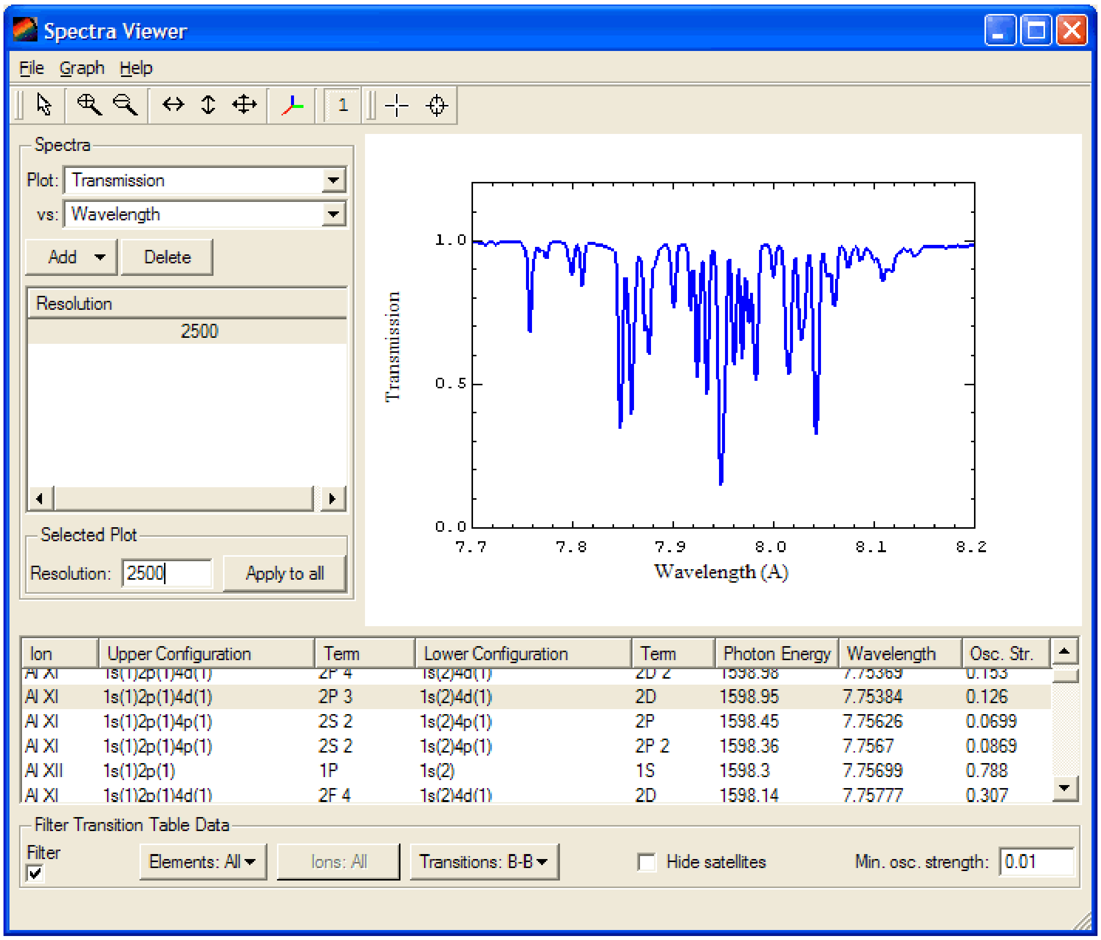

Figure 1. *PrismSPECT* screenshot from Al Kα simulation.

Figure 2 compares the *PrismSPECT* spectrum with the measured spectrum of Perry *et al.* The spectrum in the display is the Transmission vs. Wavelength, and it is convolved with an instrumental spectral resolution of $\lambda/\Delta\lambda = 2500$.

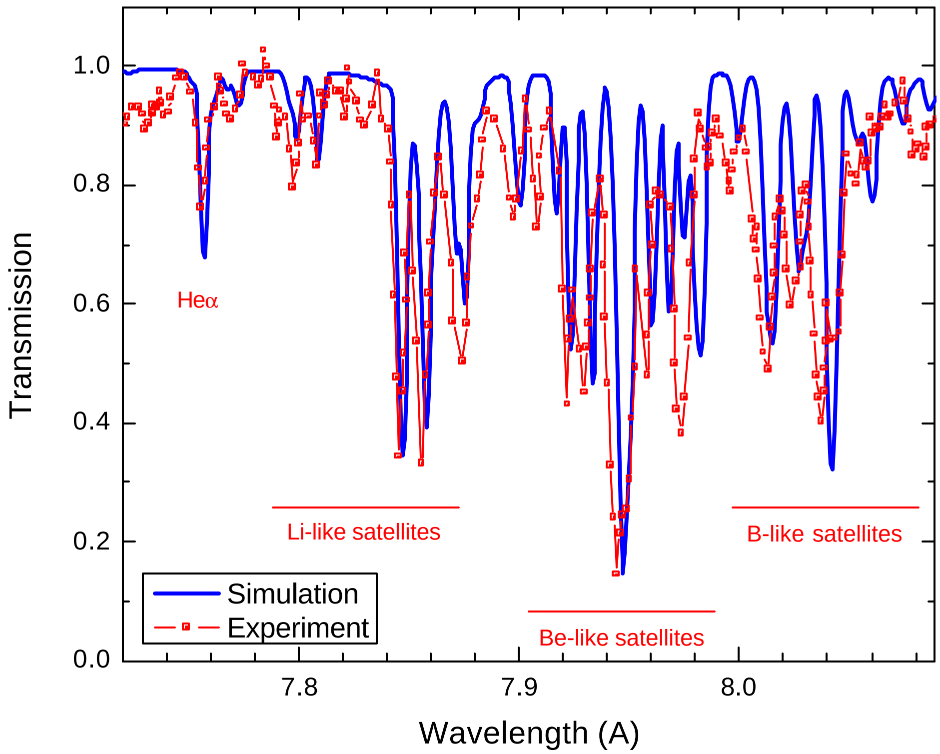

Figure 2. Comparison of *PrismSPECT* Al Kα satellite spectrum calculated for T = 58 eV and r = 0.02 g/cm^3 with experimental data of Perry *et al*.