# Radiation transport modeling for Xe and Sn-doped droplet laser-plasma sources

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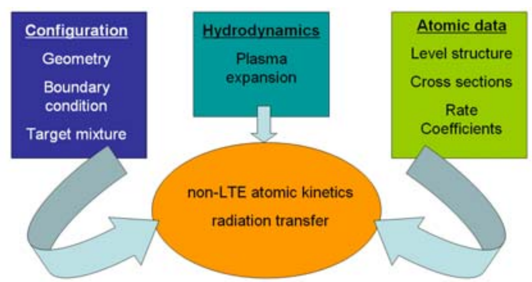
## Radiation transport modeling for mass-limited droplet high Z laser plasma EUV emission using Cretin code

Cretin combines non-LTE atomic kinetics, radiation transfer, and other plasma processes



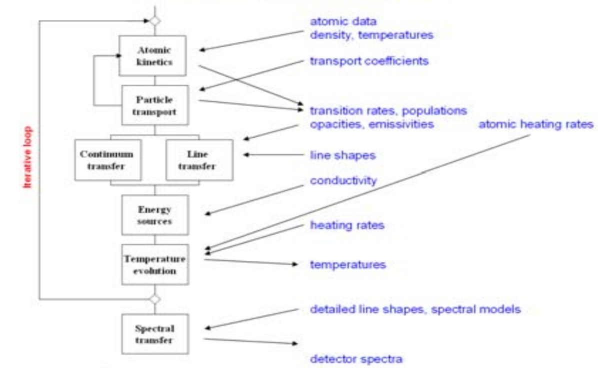

## All physical data in Cretin are based upon atomic kinetics

- *Atomic processes included: (+ all inverse processes)*
  - *radiative excitation, ionization*
  - *electron-ion, and ion-ion collisional excitation, ionization*
  - *Auger processes (auto-ionization, dielectronic recombination)*
- *Implicit solution for populations (steady-state or time-dependent)*
- *Iterated to consistency with all other physical processes*
- *All radiative processes contribute to opacities and emissivities*

## Line transfer includes multiple effects

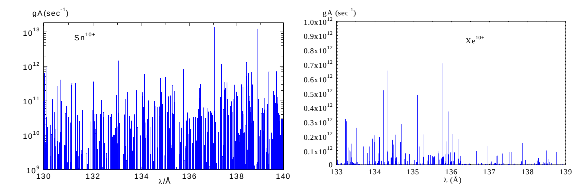
- *Self-consistency with atomic kinetics achieved through linearization*
  - *applied to groups of interacting lines*
  - *equivalent to an optimized ETLA, generalized to multiple lines*
- *Direct solution in 1D, accelerated lambda iteration in 2D / 3D*
- *Includes overlapping / interacting lines and material velocities*
- *Voigt, partial redistribution, or Stark line profiles*
- *Escape factors provide a fast approximation in 1D*

## Cretin computational cycle



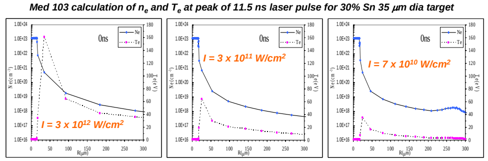

## We use the Cowan and FAC codes for Atomic data

**Cowan code prediction of $Sn^{+10}$ and $Xe^{+10}$ line emission in the 13.5 nm region**

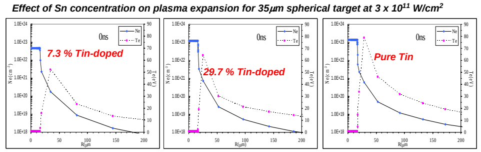



**Laser coupling, energy transport and plasma expansion is modeled with a Lagrangian fluid code (MED 103)**

*Med 103 calculation of $n_e$ and $T_e$ at peak of 11.5 ns laser pulse for 30% Sn 35 µm dia target*



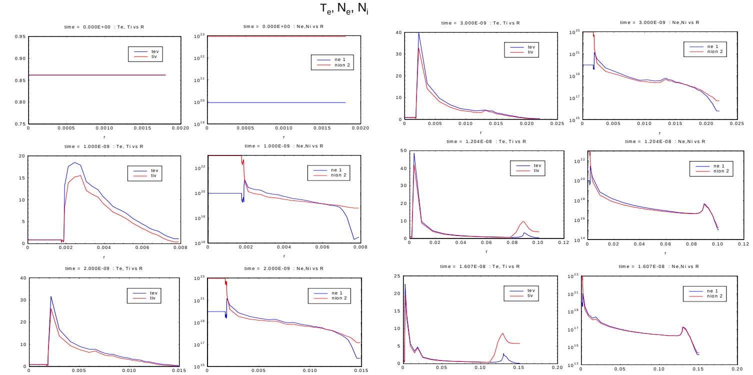

*Effect of Sn concentration on plasma expansion for 35µm spherical target at $3 \times 10^{11}$ W/cm$^2$*




## Initial CRETIN Results

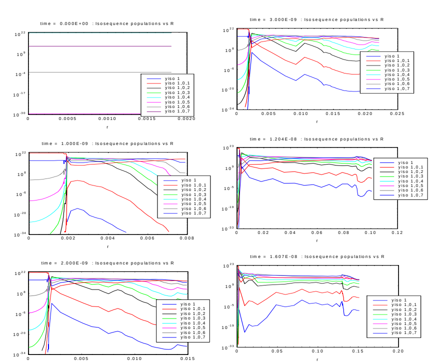
Plasma properties for Sn Droplet plasma

$T_e$, $N_e$, $N_i$

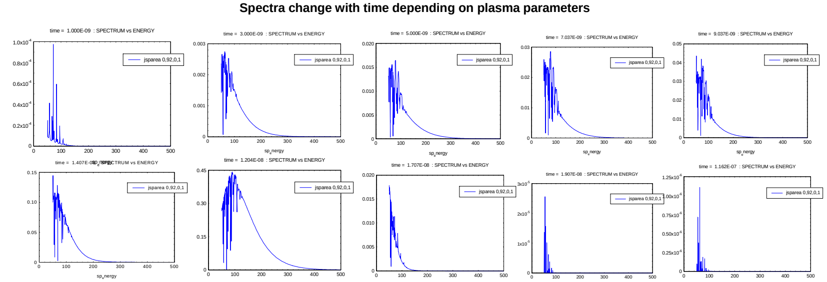


Plasma properties for Sn Droplet plasma

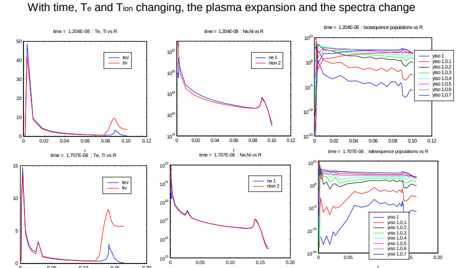
Isosequence populations



**Spectra change with time depending on plasma parameters**



With time, $T_e$ and $T_{ion}$ changing, the plasma expansion and the spectra change



**For spherical geometry**

**The area-integrated intensity for a spectral group in (erg/sec/Hz/ster), vs energy for the spectral group in (eV).**

**What missing?**

**We are working on complete the atomic data for Sn and Xe by adding the cross sections and Rate coefficients for all atomic processes mentioned above.**

- In this calculations:
- For droplet plasma we treated the plasma as a sphere.
- We used a hydrogenic model for Sn.

## Summary

Integrated plasma generation/expansion and radiation transfer approach to modeling spherical Xe and Sn laser plasma sources for EUV

Laser – plasma coupling physics, electron transport and plasma expansion treated with 90 cell, time-sequenced, self-consistent Lagrangian two fluid code (Med 103).

Radiation transfer and emission treated with 1D/2D non-LTE radiation transfer code (CRETIN).

Basic atomic physics of ion emission treated with COWAN and FAC codes.

Initial modeling results with Sn and Xe laser plasmas, but without complete atomic physics data.