Intra-beam scattering (IBS) of a high brightness electron beam in a linac has been studied analytically, and the expectations found to be in reasonable agreement with particle tracking results from the Elegant code. It comes out that, under standard conditions for a linac driving a free electron laser, IBS plays no significant role in the development of microbunching instability. A partial damping of the instability is envisaged, however, when IBS is enhanced either with dedicated magnetic insertions, or in the presence of an electron beam charge density at least 4 times larger than that produced by present photo-injectors.

\[ \frac{1}{\sigma_z^2} \frac{d\sigma_z}{dt} = \frac{r_z^2 c N}{8 y' e_z \sigma_z \sigma_z \ln \frac{\Delta Y_{\text{max}}}{\Delta Y_{\text{min}}}} \]  

**LOW-\(\beta\) FODO CHANNEL as an alternative to a LASER HEATER:**  
- The idea of using IBS to increase the energy spread of an electron bunch traveling in a dedicated FODO channel seems to be attractive for the following reasons:  
  i) IBS heats the beam by avoiding cost, complexities and maintenance of a laser heater system;  
  ii) the heating level is tunable with the quadrupoles’ focusing strength;  
  iii) it provides longitudinally uncorrelated energy spread, thus avoiding any side effect associated to the energy modulation induced in a LH at the infrared laser wavelength (e.g., the so-called trickle heating)

\[ \sigma_z^2 = \sigma_{z,0}^2 + \frac{2 y^2 e_z c N}{\gamma' \gamma_z \sigma_z \sigma_z} \Delta s = \sqrt{\sigma_{z,0}^2 + \sigma_{z,\text{IBS}}^2}, \]  

**ANALYTICAL ESTIMATION:**  
- IBS-induced rms energy spread in keV, in the \((\beta, Q)\) space for \(L = 30\) m (left), and in the \((\beta, L)\) space for \(Q = 500\) pC. Both plots are for a beam energy of 150 MeV.
- The beam transverse emittances and the bunch duration are scaled with \(Q\) in order to keep the 3-D charge density constant.

**INTRA BEAM SCATTERING in RECIRCULATION:**  
- A recirculating IBS beam line (RIBS) could be used to cumulate a larger \(\sigma_{d,\text{IBS}}\) and to minimize the impact on the total linac length. The two arcs are achromatic and quasi-isochronous. An ultra-relativistic bunch takes approximately 360 ns to make one turn in the RIBS. Kickers with rise and fall time pulse duration of a few tens of nanosecond are therefore adequate for our purposes.

**CONCLUSIONS:** A relatively compact single-pass low-beta FODO channel at the linac injection could almost double the incoherent energy spread of high brightness beams with charge in the range 100–500 pC. A beam heating above the 10 keV rms level is envisaged at the end of the FODO channel for charge densities at least 4 times higher than generated by state-of-the-art photo-injectors.

Reference: S. Di Mitri, Phys. Rev. ST – Accel. Beams, 17, 074401 (2014).