The importance of multiple scatterings in medium-induced gluon radiation

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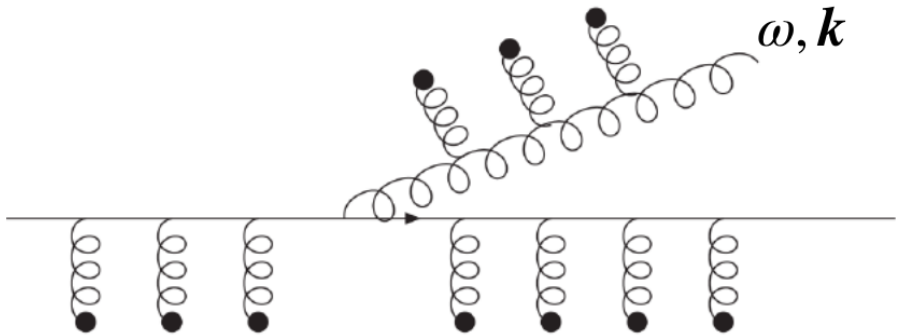
Carlota Andres, Fabio Dominguez, MGM: JHEP 03 (2021) 102

Energy loss

- Jet quenching: partons interact with QGP and lose energy



- Two available analytical approximations
  - Harmonic oscillator: multiple soft scatterings
  - First opacity or GLV approximation: one single hard scattering

Medium-induced gluon spectrum

- Emission spectrum off a parton with energy E of a soft gluon (BDMPS-Z):

$$\omega \frac{dI}{d\omega d^2\boldsymbol{k}} = \frac{2\alpha_s C_R}{(2\pi)^2\omega^2} \mathrm{Re} \int_0^\infty dt' \int_0^{t'} dt \int_{\boldsymbol{pq}} \boldsymbol{p}\cdot\boldsymbol{q}\, \widetilde{\mathcal{K}}(t',\boldsymbol{q};t,\boldsymbol{p})\mathcal{P}(\infty,\boldsymbol{k};t',\boldsymbol{q})$$

- Recently, new method with no approximations. Full solution obtained numerically by solving two differential equations

$$\partial_\tau \mathcal{P}(\tau,\boldsymbol{k};s,\boldsymbol{l}) = -\frac{1}{2}n(\tau)\int_{\boldsymbol{k}'}\sigma(\boldsymbol{k}-\boldsymbol{k}')\mathcal{P}(\tau,\boldsymbol{k}';s,\boldsymbol{l})$$

$$\partial_t \widetilde{\mathcal{K}}(s,\boldsymbol{q};t,\boldsymbol{p}) = \frac{i\boldsymbol{p}^2}{2\omega}\widetilde{\mathcal{K}}(s,\boldsymbol{q};t,\boldsymbol{p}) + \frac{1}{2}n(t)\int_{\boldsymbol{k}'}\sigma(\boldsymbol{k}'-\boldsymbol{p})\widetilde{\mathcal{K}}(s,\boldsymbol{q};t,\boldsymbol{k}')$$

Carlota Andres, Liliana Apolinario, Fabio Dominguez: JHEP 07 (2020) 114

Small energy limit (Bethe-Heitler)

$$\omega \frac{dI^{\text{med}}}{d\omega}\bigg|_{\omega\to 0} = \frac{2\alpha_s C_R}{\omega}\,\text{Re}\int_0^L ds\, n_0 \int_0^s dt \int_{\boldsymbol{pq}} i\,\frac{\boldsymbol{p}\cdot\boldsymbol{q}}{\boldsymbol{q}^2}\sigma(\boldsymbol{q}-\boldsymbol{p})\, e^{-\left(i\frac{p^2}{2\omega}+\frac{1}{2}n_0\Sigma(p^2)\right)(s-t)}$$

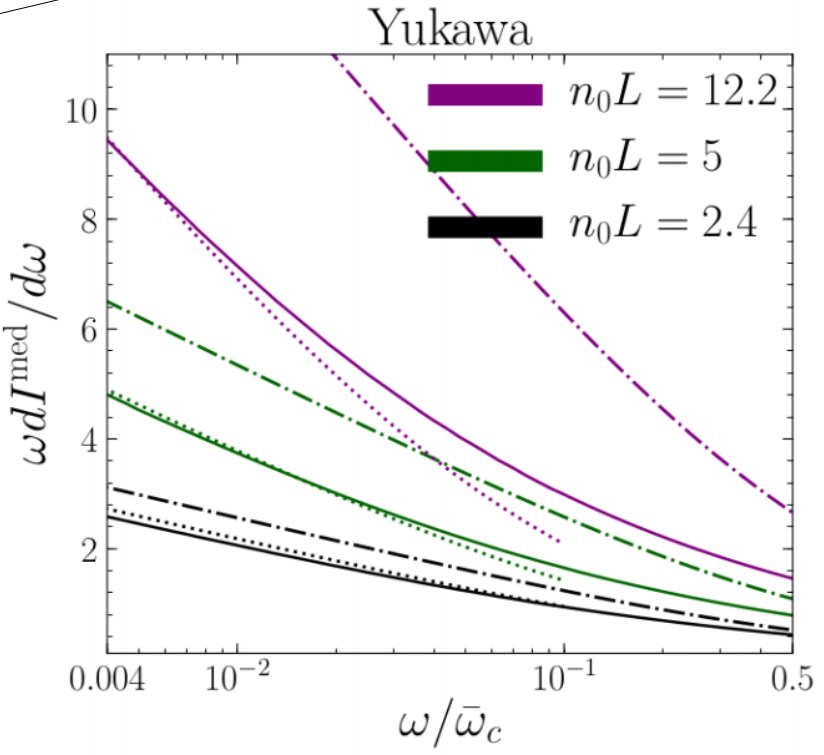
GLV, one hard scattering

Probability of not experiencing any further scatterings

— Full

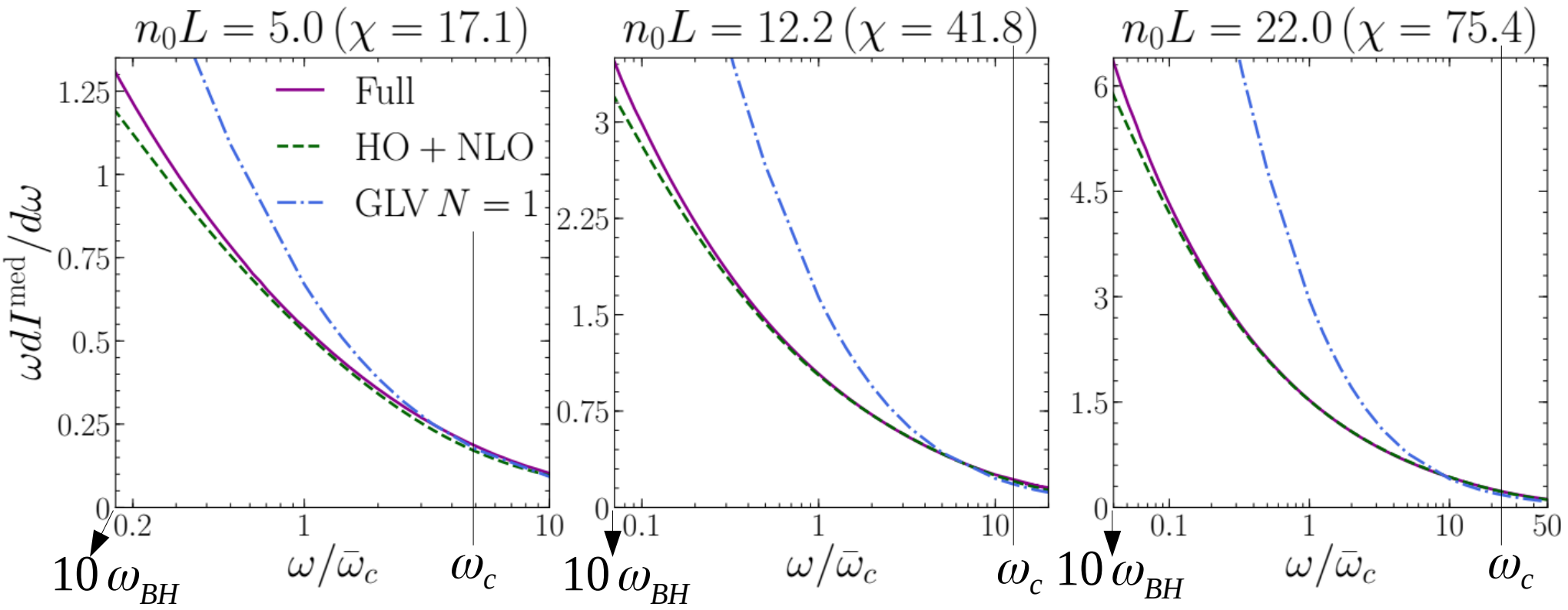
···· Low-ω formula

–·– GLV N=1



$$\bar{\omega}_c = \frac{1}{2}\mu^2 L$$

Multiple scattering regime



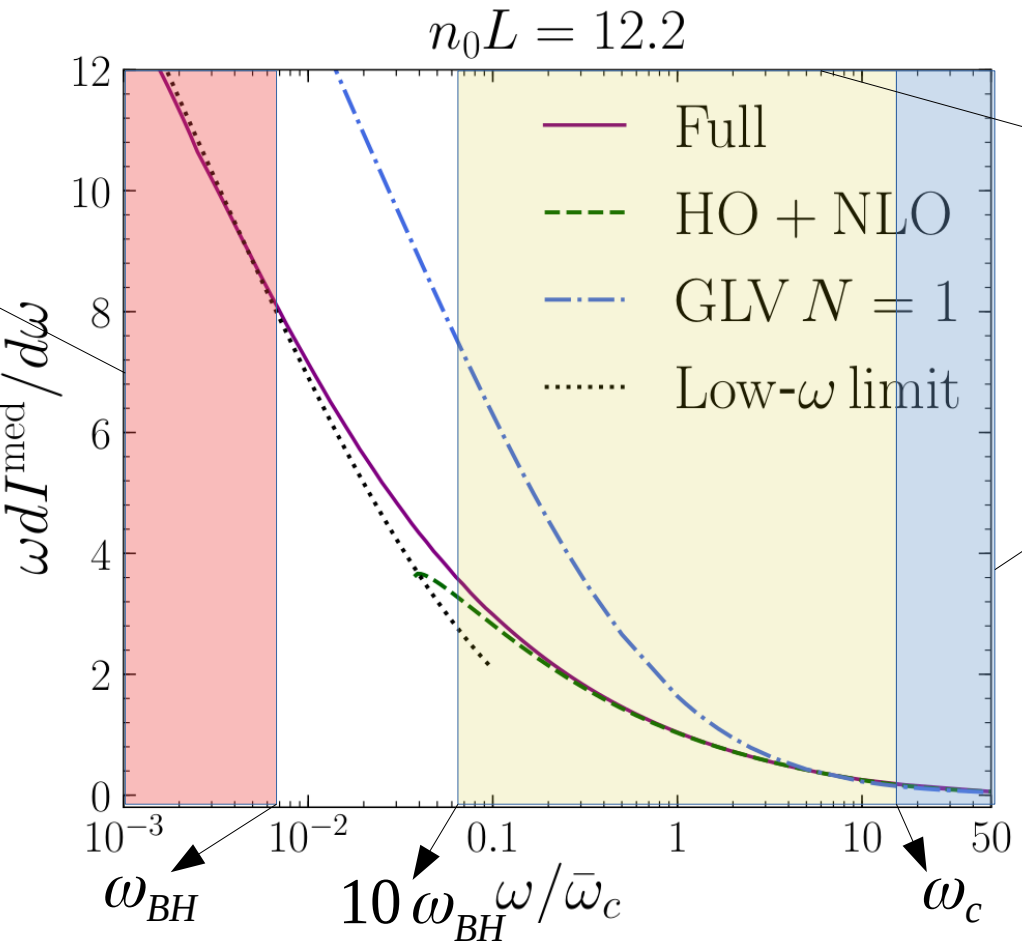
IOE works well in its range of applicability

Yacine Mehtar-Tani, arXiv:1903.00506

Coherence effects between multiple scatterings are essential in this region

Summary

$$\bar{\omega}_c = \frac{1}{2}\mu^2 L$$



Bethe-Heitler regime

Multiple scattering regime

GLV: single scattering