

# Probing small scale fluctuation with 21cm absorption

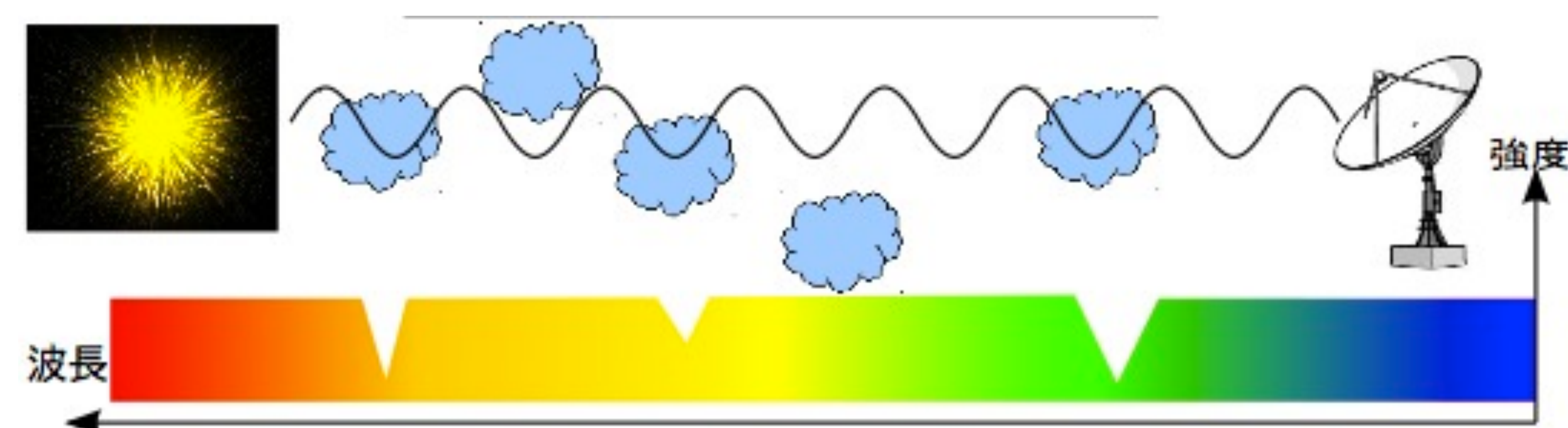
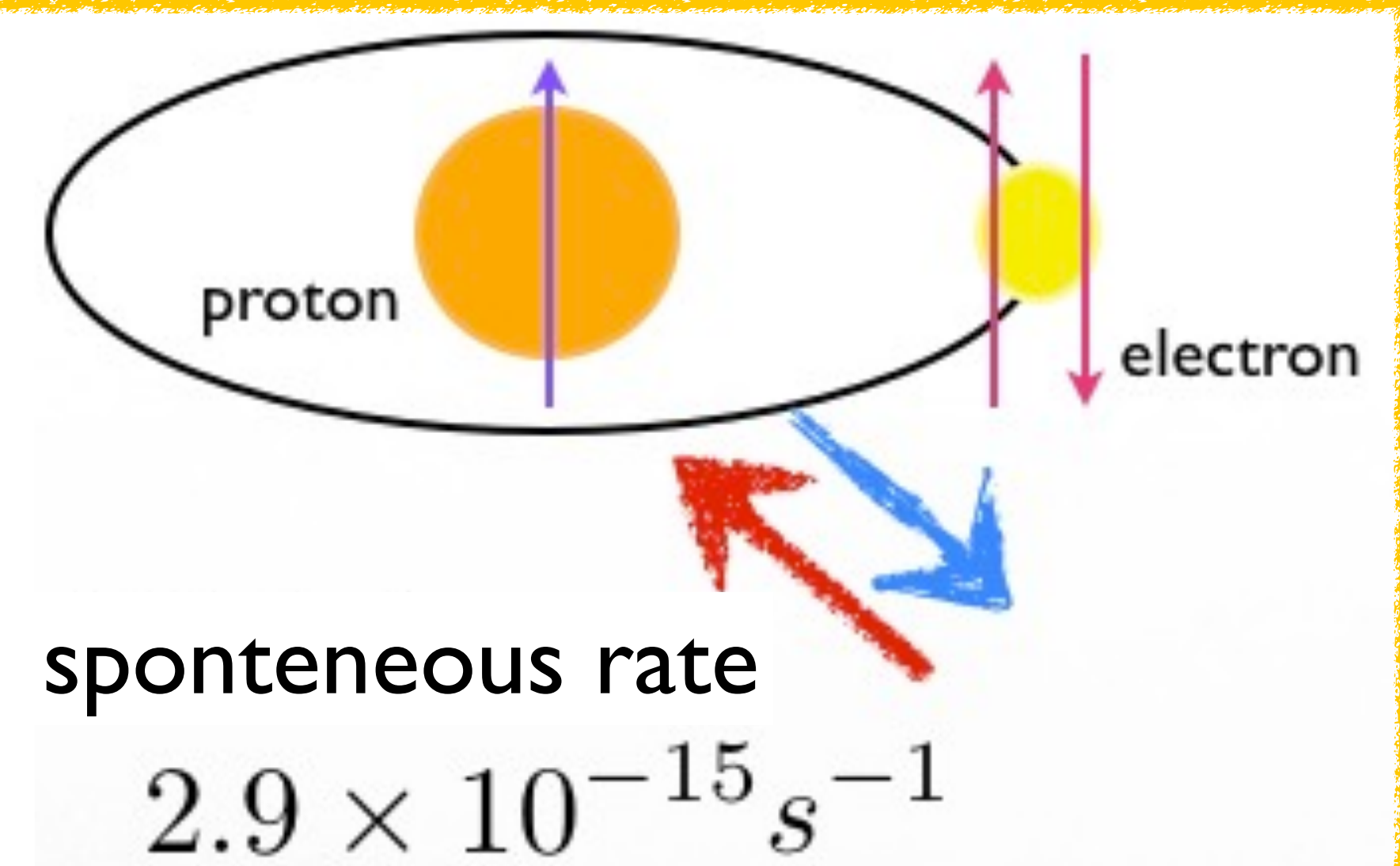
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## Motivation

Standard cosmology model ( $\Lambda$ CDM model) matches the observations of the universe. However observations do not reach small scale (sub-galactic scale) structure of the universe. New physical effects such as massive neutrino, running index (RI) and warm dark matter (WDM) appear in small scale fluctuations. Although we have not observed this small scale structure yet, future observations such as SKA (Square Kilometer Array) are expected to search small scale structures. We studied how to get information of small scale density fluctuation to probe new physical effects

## Method

Due to the spin flips, neutral hydrogens radiate or absorb radio waves, whose wavelength is "21cm". Radio waves radiated by distant source objects (GRB, quasar etc) are absorbed by minihalos on the way to us. We can observe this absorption lines as shaved source spectral in the frequency band corresponding to the redshifted 21cm signal. As a signal, we focus on the number of absorption line



### Optical depth

$$\tau_\nu = \frac{3h_p c^3 A_{10}}{32\pi k_B \nu_{21}^2} \int_{-R_{\max}}^{R_{\max}} dR \frac{n_{\text{HI}}(r)}{T_S(r) \sqrt{\pi} b(r)} \exp\left(-\frac{v^2(\nu)}{b^2}\right)$$

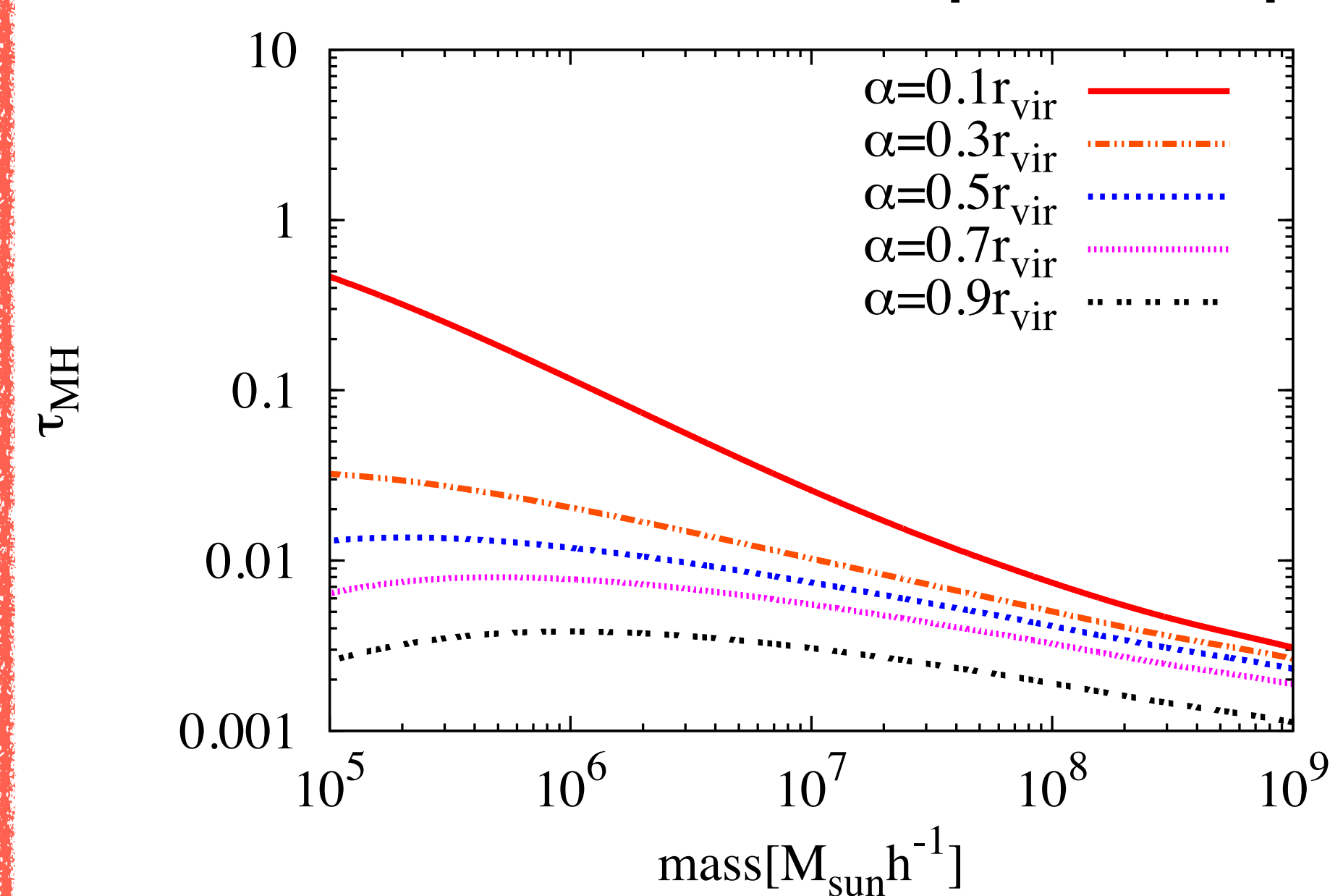
### Absorption line abundance

$$\frac{dn(> \tau_{\text{mh}})}{dz} = (1+z)^2 \frac{dr}{dz} \int_{m_{\min}}^{m_{\max}} dm \frac{dn}{dm}(m) \pi r_\tau^2(m, \tau_{\text{mh}})$$

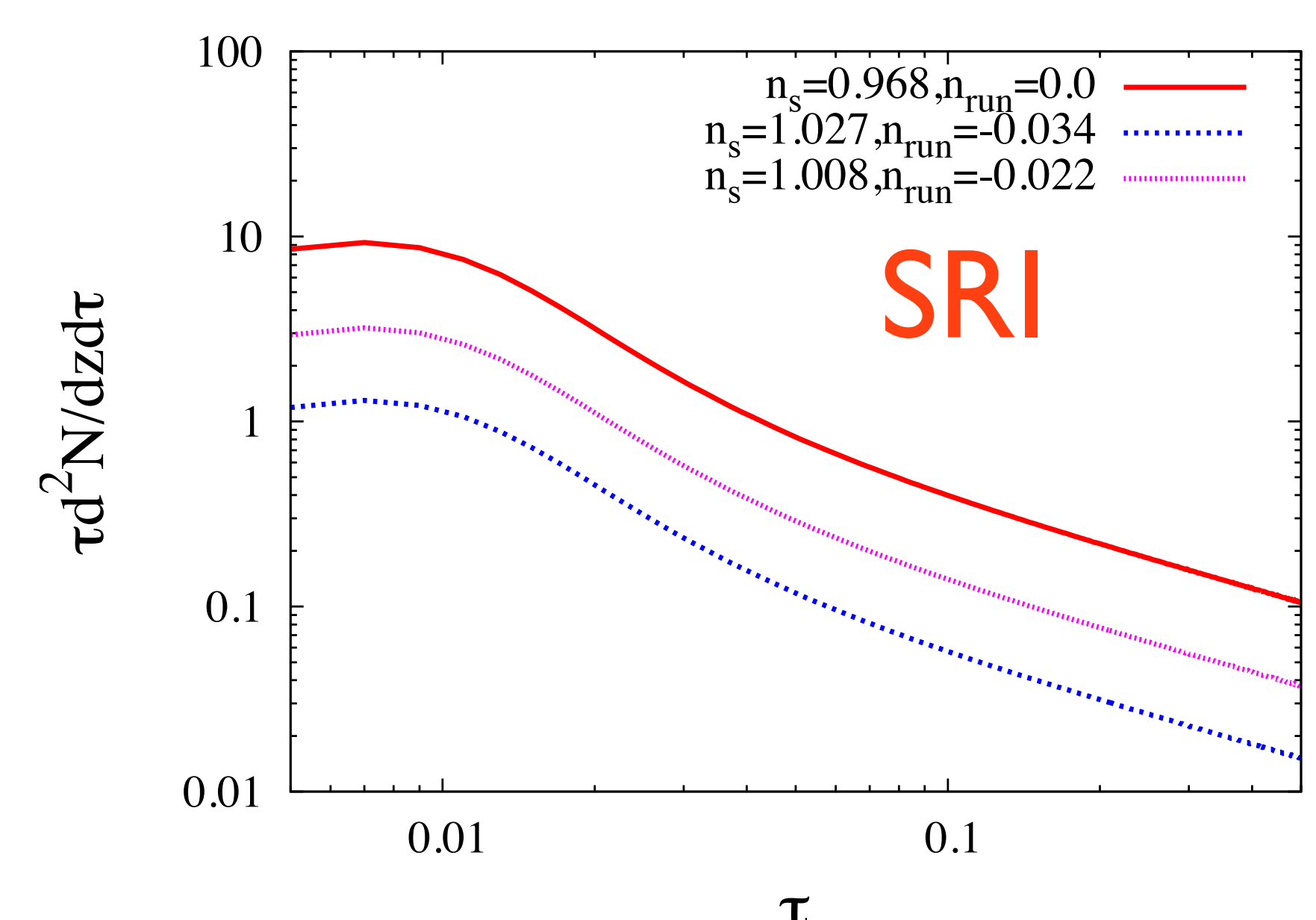
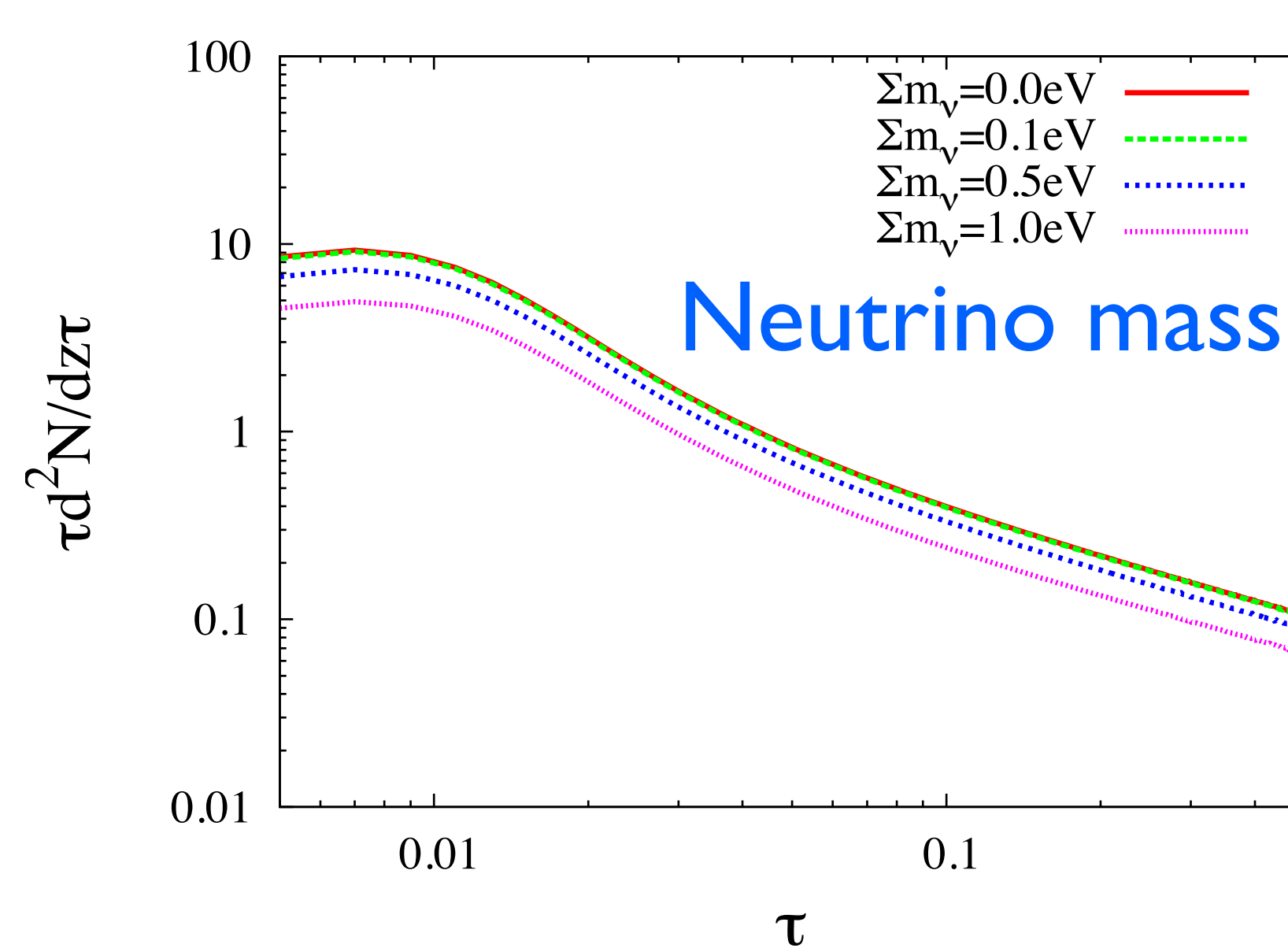
Optical depth is defined how the back ground flux is absorbed. We calculated optical depth absorbed by minihalos and distribution of absorption line abundance for optical depth. Through the absorption line abundance, we probe some cosmological effects on small scale density fluctuation (massive neutrino, RI, WDM)

## Result & Discussion

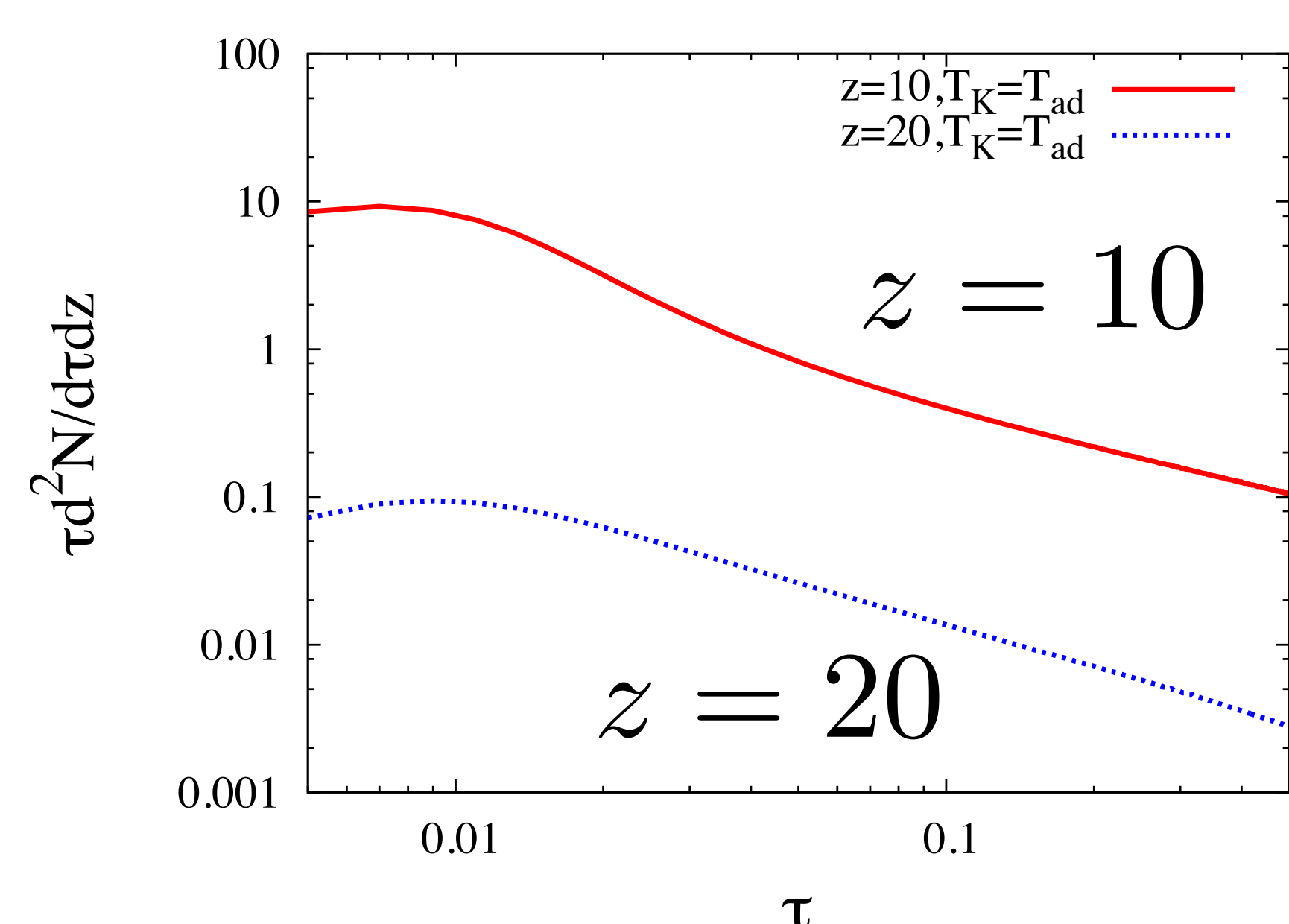
### minihalo mass - Optical depth



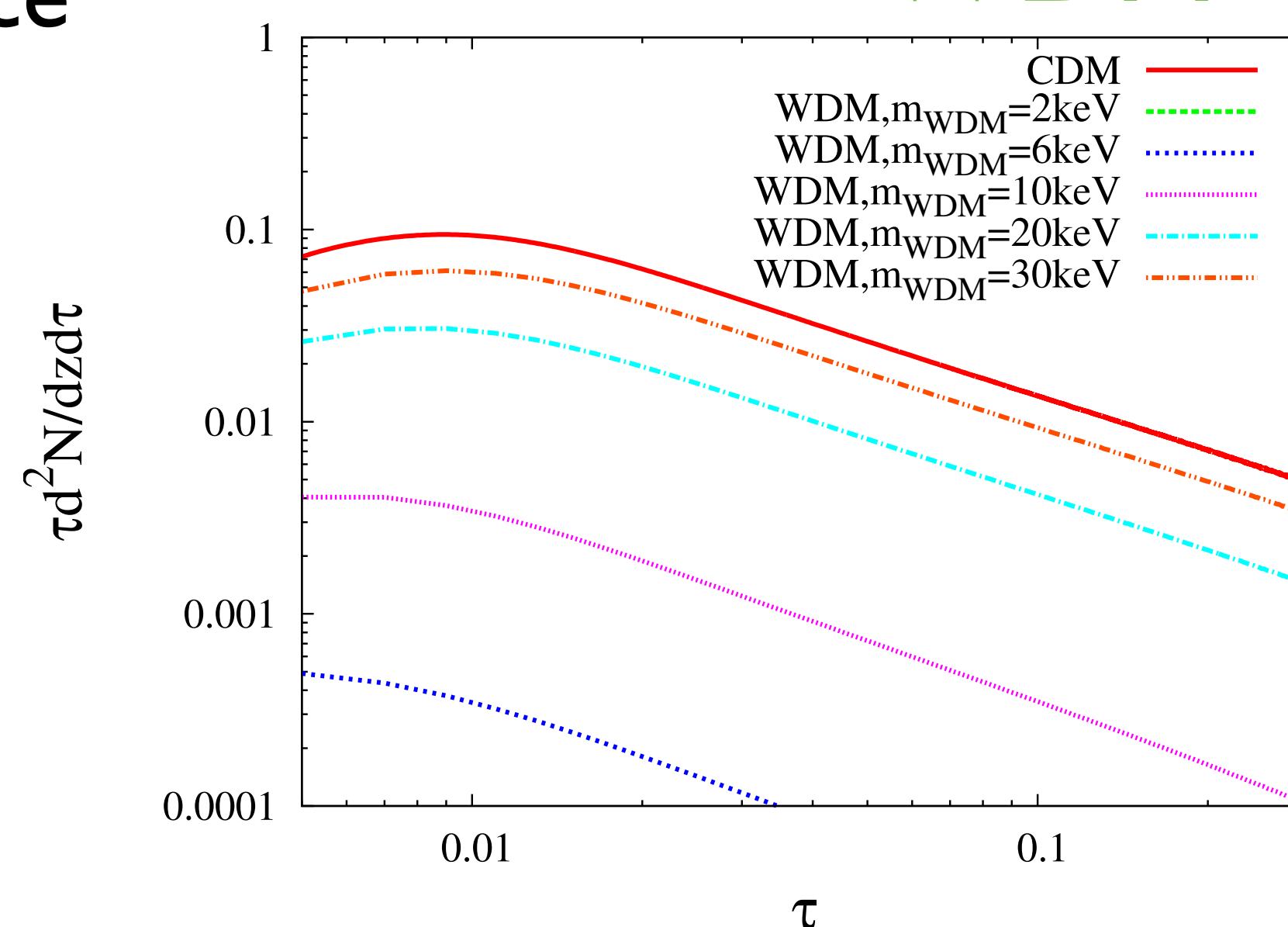
### cosmological effects



### Optical depth - absorption line abundance



### WDM



We show some results. The main result is the relation between optical depth and absorption line abundance. We expect that these two values are observable by future observation such as SKA.

The method using 21cm absorption can provide us more constraint on RI and WDM than current constraint, although constraint for neutrino mass is difficult. Thus we have a chance to get a new insight into inflation model and the nature of WDM.