WORK UPDATE

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UNIVERSIDADE DE SÃO PAULO | AUGUST 14, 2024

OVERVIEW

1 - Study of covariant derivatives

2 - Study of spinors

3 - Study of the tetrad

4 - Study of spin connection

5 - Study of Clifford algebra

LAGRANGIAN

- **Old**

$$L = \frac{1}{2}\partial^{\mu}\phi\partial_{\mu} - V(\phi) + \bar{\psi}(i\overleftarrow{\partial} - M)\psi + \phi\bar{\psi}\psi$$

- **New**

$$L = \sqrt{-g}\{-V(\phi)\sqrt{1-\alpha\partial^{\mu}\phi\partial_{\mu}\phi} + \frac{i}{2}[\bar{\psi}\gamma^{\mu}\nabla_{\mu}\psi - \bar{\psi}\overleftarrow{\nabla}_{\mu}\gamma^{\mu}\psi] - (M-\beta\phi)\bar{\psi}\psi\}$$

TACHYONIC FIELD

$$L = \sqrt{-g}\{-V(\phi)\sqrt{1 - \alpha\partial^{\mu}\phi\partial_{\mu}\phi}$$

Energy density and the pressure density of the tachyon scalar field model:

$$\rho = \frac{V(\phi)}{\sqrt{1 - \dot{\phi}^2}}$$

$$P = -V(\phi)\sqrt{1 - \dot{\phi}^2}$$

FERMIONIC FIELD

$$\frac{i}{2}[\bar{\psi}\gamma^{\mu}\nabla_{\mu}\psi - \bar{\psi}\overleftarrow{\nabla}_{\mu}\gamma^{\mu}\psi]$$

$$C^{\mu}_{\kappa\lambda} = -4\pi G\epsilon_{abcd}e^{a}_{\lambda}e^{b}_{\kappa}e^{c\mu}(\bar{\psi}\gamma_5\gamma^{d}\psi)$$

$$K^{\lambda}_{\nu\mu} = -2\pi G\epsilon_{abcd}e^{a}_{\mu}e^{b}_{\nu}e^{c\lambda}(\bar{\psi}\gamma_5\gamma^{d}\psi)$$

Introducing the symmetric Ricci tensor: $R_{\mu\nu} = \tilde{R}_{\mu\nu} + \tilde{\nabla}_{\lambda}K^{\lambda}_{\mu\nu} - \tilde{\nabla}_{\nu}K^{\lambda}_{\mu\lambda} + K^{\lambda}_{\theta\lambda}K^{\theta}_{\mu\nu} - K^{\lambda}_{\theta\nu}K^{\theta}_{\mu\lambda}$

$$\tilde{R}_{\mu\nu} - \frac{1}{2}\tilde{R}g_{\mu\nu} = 8\pi G(\tilde{T}_{\mu\nu} - \frac{3}{2}\pi G g_{\mu\nu}\sigma^2)$$

NEXT STEPS

- Tensor pertubation for fermionic field
- CLASS

alcides.vicente@cosmo0: ~/C

```
#
# -> if you prefer output in CAMB/HealPix/LensPix units/order, set 'format' to 'camb' in input file
# -> if you don't want to see such a header, set 'headers' to 'no' in input file
# -> for CMB lensing (phi), these are C_l^phi-phi for the lensing potential.
#    Remember the conversion factors:
#    C_l^dd (deflection) = l(l+1) C_l^phi-phi
#    C_l^gg (shear/convergence) = 1/4 (l(l+1))^2 C_l^phi-phi
#
# 1:l     2:TT                    3:EE                    4:TE                    5:BB                    6:phiphi
            7:TPhi                  8:Ephi
     2      1.404305087108e-10      5.182392798948e-15      3.897398229419e-13      0.000000000000e+00      8.328634
519037e-09      4.654920130753e-10      -2.059561357077e-12
     3      1.325290292153e-10      7.446442600614e-15      4.589184267630e-13      0.000000000000e+00      5.084366
004490e-09      3.293216034626e-10      -1.667994827860e-12
     4      1.250085333600e-10      7.281585906855e-15      4.472542531455e-13      0.000000000000e+00      3.528716
116503e-09      2.491049265376e-10      -1.194672552031e-12
     5      1.192731114781e-10      5.531188719197e-15      3.955420357531e-13      0.000000000000e+00      2.619506
212406e-09      1.966181163637e-10      -7.625969446411e-13
     6      1.152516403912e-10      3.464613201530e-15      3.292652694992e-13      0.000000000000e+00      2.040065
194019e-09      1.598901093992e-10      -4.116584341388e-13
     7      1.126136674560e-10      1.924330768169e-15      2.644077824186e-13      0.000000000000e+00      1.641136
7747797e-09      1.329384335627e-10      -1.550999202817e-13
     8      1.109583013716e-10      1.105162215578e-15      2.094454657941e-13      0.000000000000e+00      1.352895
110181e-09      1.124470687839e-10      9.6419689306 72e-15
     9      1.100985272189e-10      7.911648734672e-16      1.680373319566e-13      0.000000000000e+00      1.136915
326081e-09      9.648263094699e-11      9.511561168800e-14
    10      1.098448341413e-10      6.852895378100e-16      1.480432042403e-13      0.000000000000e+00      9.702839
697314e-10      8.381531595207e-11      1.196818470011e-13
    11      1.100070012772e-10      6.974803561535e-16      1.258009852578e-13      0.000000000000e+00      8.310422973254e-10      7.427411362106e-11      1.037537755311e-13
    12      1.105527993374e-10      5.186527643866e-16      1.208969832918e-13      0.000000000000e+00      7.268472361994e-10      6.578358317214e-11      6.701046202858e-14
    13      1.113495899980e-10      4.481728358072e-16      1.228519060880e-13      0.000000000000e+00      6.398566843841e-10      5.867813063624e-11      2.487788372596e-14
    14      1.123677738049e-10      4.210819271608e-16      1.289086186422e-13      0.000000000000e+00      5.681519008433e-10      5.264550828855e-11      -1.155258667909e-14
    15      1.135201843317e-10      4.327036319947e-16      1.369381816230e-13      0.000000000000e+00      5.078028536465e-10      4.755812491806e-11      -3.603790485879e-14
    16      1.148459736594e-10      4.628738248884e-16      1.454631601526e-13      0.000000000000e+00      4.564951732576e-10      4.320355929953e-11      -4.698476168460e-14
    17      1.162966147486e-10      4.984478028560e-16      1.536776020916e-13      0.000000000000e+00      4.124856414927e-10      3.937188827107e-11      -4.626103396763e-14
    18      1.178464650474e-10      5.421957444395e-16      1.613412121429e-13      0.000000000000e+00      3.742953717545e-10      3.599780567649e-11      -3.765644180635e-14
    19      1.194976360677e-10      6.035395360864e-16      1.686553790887e-13      0.000000000000e+00      3.413048797651e-10      3.304216498065e-11      -2.505115332398e-14
    20      1.212093586417e-10      6.924899532311e-16      1.759792102925e-13      0.000000000000e+00      3.122545768496e-10      3.039362385799e-11      -1.298257237758e-14
    21      1.229912121585e-10      8.095022392855e-16      1.836258776879e-13      0.000000000000e+00      2.866858975902e-10      2.805197678598e-11      -3.905563030686e-15
    22      1.248376386126e-10      9.508917277756e-16      1.918588269560e-13      0.000000000000e+00      2.639815602939e-10      2.608972435387e-11      5.856652247094e-16
    23      1.267467793450e-10      1.114547629876e-15      2.006482837858e-13      0.000000000000e+00      2.438365174244e-10      2.421389448061e-11      6.212074529831e-16
    24      1.286973377485e-10      1.298620017681e-15      2.097914151764e-13      0.000000000000e+00      2.257897356727e-10      2.257527031265e-11      -2.724501481498e-15
    25      1.306904397564e-10      1.503464353781e-15      2.189494134169e-13      0.000000000000e+00      2.095956052707e-10      2.107378512239e-11      -7.866577522241e-15
    26      1.327210446523e-10      1.729857597048e-15      2.276991279793e-13      0.000000000000e+00      1.949363796914e-10      1.969914926530e-11      -1.292614958737e-14
    27      1.347983236592e-10      1.977628447808e-15      2.357464443728e-13      0.000000000000e+00      1.817355427814e-10      1.845280244592e-11      -1.695555873977e-14
    28      1.369195034590e-10      2.245986339246e-15      2.427941079296e-13      0.000000000000e+00      1.698325814232e-10      1.732638233194e-11      -1.918435417597e-14
    29      1.390675972263e-10      2.534361385785e-15      2.485479045627e-13      0.000000000000e+00      1.589377846305e-10      1.629914848414e-11      -1.896735168698e-14
    30      1.412463149113e-10      2.844938691068e-15      2.529357545324e-13      0.000000000000e+00      1.489907339108e-10      1.536383928368e-11      -1.674580148639e-14
    31      1.434553205707e-10      3.181182287947e-15      2.559839693731e-13      0.000000000000e+00      1.399172750641e-10      1.450844577207e-11      -1.349742672400e-14
    32      1.456861805237e-10      3.546571498604e-15      2.577565766230e-13      0.000000000000e+00      1.315734611397e-10      1.371454942836e-11      -1.031614653506e-14
    33      1.479459092802e-10      3.942246181614e-15      2.583643205077e-13      0.000000000000e+00      1.239136123884e-10      1.297923842794e-11      -7.704771818566e-15
```

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THANK YOU

WORK UPDATE

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UNIVERSIDADE DE SÃO PAULO | SEPTEMBER 11, 2024

POWER SPECTRUM

- tCl (Temperature Power Spectrum)
- pCl (Polarization Power Spectrum)
- lCl (Lensing Power Spectrum)
- As (Amplitude of the Primordial Spectrum)
- mPk (Power Spectrum of Matter)
- pCl (Polarization Power Spectrum)

CLASS

```
#number_count_contributions =     # nCl contributions
#(density,lensing,rsd,gr) -> (density, lensing, rsd+doppler, all others)
selection=gaussian                # nCl window function type
#selection_mean=1.0,1.25,2.0,3.5  # Mean redshifts of nCl window functions
#selection_width = 0.1            # Widths of nCl window functions
#selection_bias =                 # Biases of nCl window functions
#selection_magnification_bias =   # Biases of lensing of nCl
#non_diagonal=3                   # Number of non-diagonal terms

l_max_scalars = 3000              # lmax of CMB for scalar mode
#l_max_tensors = 500              # lmax of CMB for tensor mode
#l_max_lss = 300                  # lmax of nCl

P_k_max_h/Mpc = 2.                # Maximum k for P(k) in 1/Mpc
#P_k_max_1/Mpc = 0.7              # Maximum k for P(k) in h/Mpc
z_pk = 0.13                          # Redshifts of P(k,z)
```

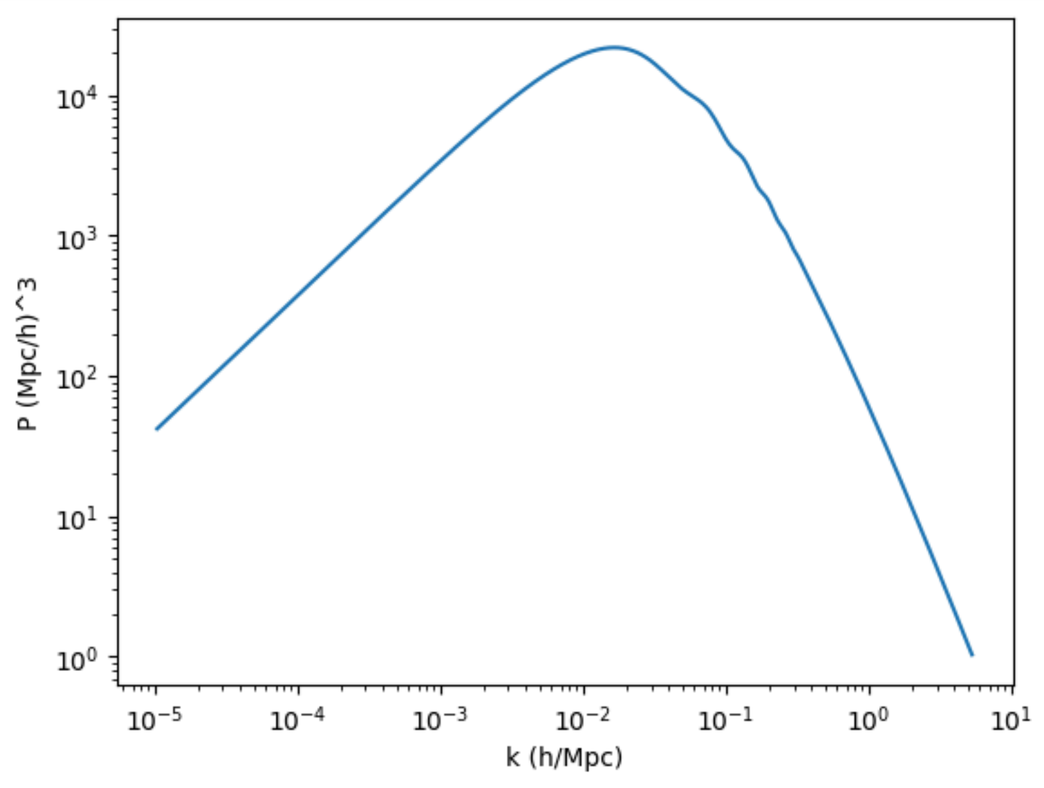
CLASS

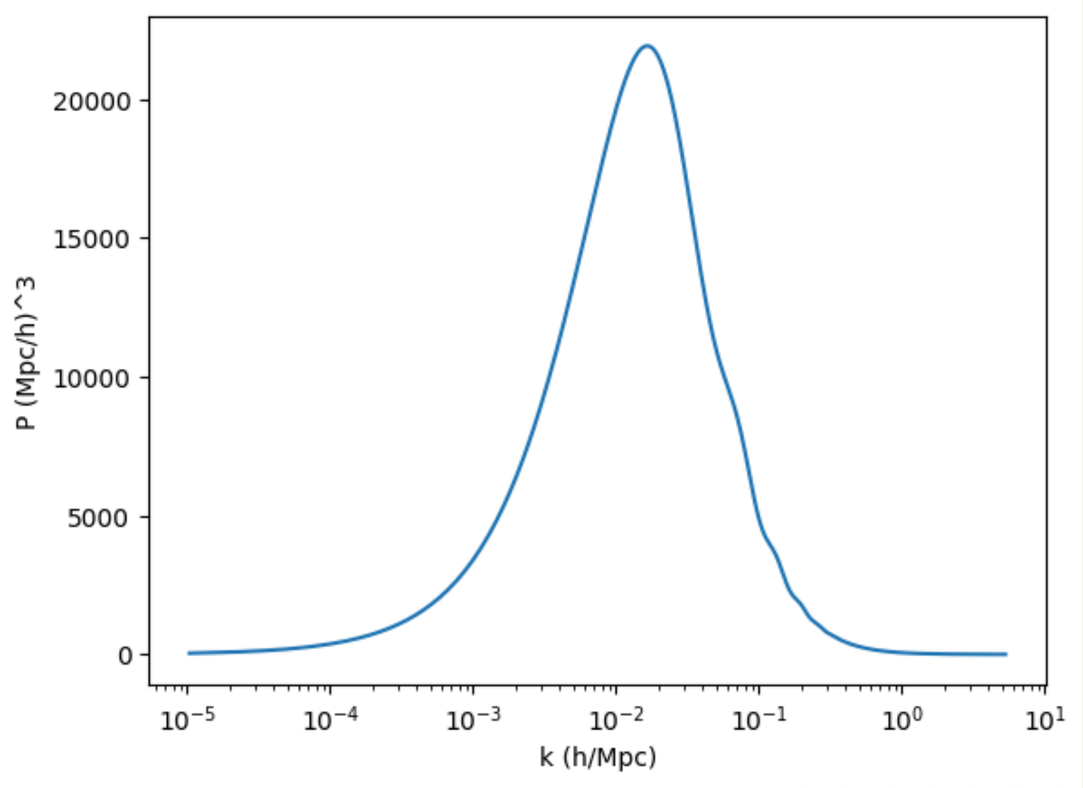
```
h = 0.67810                         # Dimensionless reduced Hubble parameter (H_0 / (100km/s/Mpc))
#H0 = 67.810                        # Hubble parameter in km/s/Mpc
#100*theta_s = 1.041783             # Angular size of the sound horizon, exactly 100(ds_dec/da_dec)
                                    # with decoupling time given by maximum of visibility function
                                    # (different from theta_MC of CosmoMC and
                                    # slightly different from theta_* of CAMB)
T_cmb = 2.7255                      # CMB temperature

omega_b = 0.02238280                # Reduced baryon density (Omega*h^2)
#Omega_b =                          # Baryon density
omega_cdm = 0.1201075               # Reduced cold dark matter density (Omega*h^2)
#Omega_cdm =                        # CDM density
omega_dcdmdr = 0.0                  # Reduced decaying dark matter density (Omega*h^2)
#Omega_dcdmdr =                     # DCDM density
#Gamma_dcdm = 0.0                   # Decay constant of DCDM in km/s/Mpc
Omega_k = 0.                        # Curvature density
Omega_fld = 0                       # Dark Energy as Fluid density
Omega_scf = 0                       # Dark Energy as Scalar field density
```

CLASS

```
# ---------------------------
# ----> Primordial parameters:
# ---------------------------

P_k_ini type = analytic_Pk          # Select primordial spectrum
#('analytic_Pk','inflation_V','inflation_H','inflation_V_end','two scales','external_Pk')
k_pivot = 0.05                      # Pivot scale for A_s,n_s
A_s = 2.100549e-09                  # Amplitude of prim spectrum
#ln10^{10}A_s = 3.0980              # ln Amplitude of prim spectrum
# sigma8 = 0.848365                 # Final density averaged over 8 Mpc
n_s = 0.9660499                     # Spectrum tilt
alpha_s = 0.                        # Spectrum running of tilt
#r = 1.                             # If tensors are activated
# See explanatory.ini for more information about all the different primordial spectra
```

CLASS





NEXT STEPS

- r (Tensor-to-Scalar Ratio)
- Change more parameters

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CLASS

O CLASS (Cosmic Linear Anisotropy Solving System) é um código computacional amplamente utilizado em cosmologia para calcular perturbações lineares e prever observáveis cosmológicos, como o espectro de potência da radiação cósmica de fundo (CMB), o espectro de potência da matéria, e outros. Ele é uma ferramenta essencial para estudos de estrutura em larga escala do universo e análises de dados cosmológicos.

CLASS

1. **Versatilidade: É utilizado para diversos modelos cosmológicos, desde o modelo padrão (ΛCDM) até extensões que consideram energia escura dinâmica, gravidade modificada, neutrinos massivos, entre outros.**
2. **Eficiência: É projetado para ser rápido e eficiente, adequado tanto para simulações grandes quanto para ajustes de parâmetros em observações cosmológicas.**
3. **Modularidade: Possui uma estrutura modular que facilita a personalização e a adição de novos modelos ou extensões cosmológicas.**

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