white dwarf

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1 Master's Degree in Particle Physics and Cosmos

1.1 Cosmos Problem 9.3 White Dwarf

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For a white dwarf, the non-relativistic equation of state is given as:

$$P = \alpha \rho^{5/3}$$

And if the white dwarf is in equilibrium,

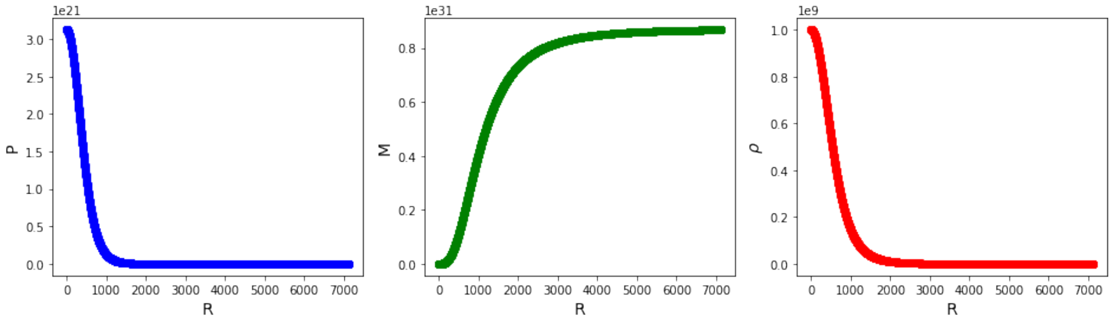
$$\frac{dP}{dr} = -\rho(r) \frac{GM(r)}{r^2}$$

In [2]:
```
import numpy as np
from matplotlib import pyplot as plt
%matplotlib inline
```

In [55]:
```
def dP(a, b):
    alpha = 3123161.171
    G = 6.67E-11
    return ((4 / 3) * np.pi * G * a * (r0 ** 2) * (b ** 2))

def white_dwarf(r0, rho_0 ,dr=1):
    """
    Builds a white dwarf
    """
    alpha = 3123161.171
    G = 6.67E-11
    m0 = (4 / 3) * np.pi * rho_0 * (r0 ** 3)
    P0 = alpha * (rho_0 ** (5/3))
    # lists
    R = [dr]
    M = [m0]
    P = [P0]
    rho = [rho_0]

    while rho[dr - 1] > 1E4:
        dr = dr + 1
```

```
        new_P = P[dr - 2] - dP(R[dr - 2], rho[dr - 2])
        new_rho = (new_P / alpha) ** (3/5)
        new_M = M[dr - 2] + ( 4 * np.pi * new_rho * ((r0 * dr)**3 - (r0 * (dr - 1))**3

        R.append(dr)
        P.append(new_P)
        rho.append(new_rho)
        M.append(new_M)

    #plot
    plt.figure(figsize=(16,4))
    plt.subplot(1, 3, 1)
    plt.plot(R,P,'ob')
    plt.xlabel("R", fontsize=14)
    plt.ylabel("P", fontsize=14)
    plt.subplot(1, 3, 2)
    plt.plot(R,M,'og')
    plt.xlabel("R", fontsize=14)
    plt.ylabel("M", fontsize=14)
    plt.subplot(1, 3, 3)
    plt.plot(R,rho,'or')
    plt.xlabel("R", fontsize=14)
    plt.ylabel(r"$\rho$", fontsize=14)
    plt.show()
```

```
In [56]: white_dwarf(1E4, 1E9)
```



It is obtained $0.10 R_{solar}$ and $1.45 M_{solar}$