Consider grand canonical partition function $Z_i(T, V, \mu_i)$
then particle density of species i

$$\rho_i = \frac{N_i}{V} = -\frac{T}{V} \frac{\partial \ln Z_i}{\partial \mu_i}$$

$$\rho_i = \frac{g_i}{2\pi^2} \cdot T_{ch}^3 \left(\frac{m_i}{T_{ch}} \right)^2 \cdot K_2\left(\frac{m_i}{T_{ch}} \right) \cdot \Lambda_B^{\sum_j \langle Q_j \rangle}$$

g_i: spin-isospin degeneracy; e.g. p: spin $\frac{1}{2} \Rightarrow g_p = 1$

T_{ch}: chemical freeze-out temperature

μ_B: quark baryo-chemical potential

K_2: modified Bessel function of the second kind

m_i: particle rest mass

$\Lambda_B = \exp(\mu_B / T_{ch})$: fugacity

$\langle Q_j \rangle = \langle u - \bar{u} + d - \bar{d} \rangle$: net number of light quarks

e.g. p: $\langle Q_j \rangle = \langle u + u + d \rangle = 3$

$\bar{p}$: $\langle Q_j \rangle = \langle \bar{u} + \bar{u} + \bar{d} \rangle = -3$

consider particle ratios:

e.g. $\bar{p}/p$-ratio at RHIC ($T_{ch} = 160$ MeV, $\mu_B = 7$ MeV)

$\bar{p}/p = \exp(-3 \cdot 7\,\text{MeV} - 3 \cdot 7\,\text{MeV} / 160) = 0.77$ | SIS $\approx 3\%$

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entropy $S_i = \frac{\partial}{\partial T}\left(k_B T \ln Z_i\right)$

at RHIC (LHC) one gets

~~Abst~~ $\frac{\langle S \rangle}{N} = 7.25\, k_B$ per hadron

at RHIC: $\frac{dN}{d\eta} = 665 \pm 26$

$dN/dy = 1.1 \frac{dN}{d\eta}$

after all resonances decayed (e.g. $\Delta^{++} \to p + \pi^+$): factor 1.04

putting all numbers together

$$\frac{dS}{dy} = (665 \cdot 1.1 \cdot 7.25) / 1.04 = 5100 \pm$$

Some remarks

$\frac{dS}{dy} = 5100 \pm 400$; one of the best known quantities in HI

~~conjectured quantum limit~~

viscosity-to-entropy ratio $\frac{\text{viscosity}}{\text{entropy dens}} = \frac{\eta}{s}$ exp. is unknown

might even be close to conjectured quantum limit: $\frac{\eta}{s} \geq \frac{1}{4\pi}$

because $\frac{dS}{dy}$ is large! also: during hydro-expansion little entropy is produced (~15%) Most at the [illegible]