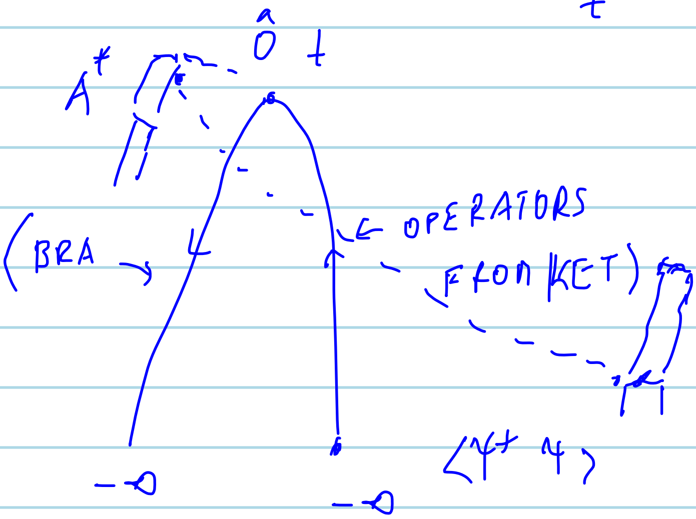
$$\left(\langle in|\right)\ \hat{O}\ \left(|in\rangle\right)$$

$t \to -\infty$ TIME $t \to -\infty$

t



$\langle \psi^{\dagger}(2)\ \psi(1) \rangle$

1-PTCLE INFO

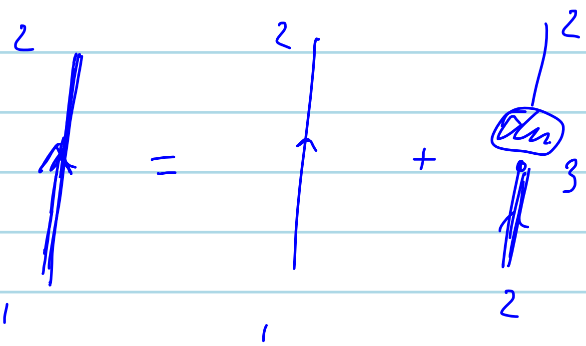
$n(1) = \langle \psi^{\dagger}(1) \psi(1) \rangle$

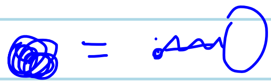
$\langle \psi(1)\ \psi^{\dagger}(2) \rangle$

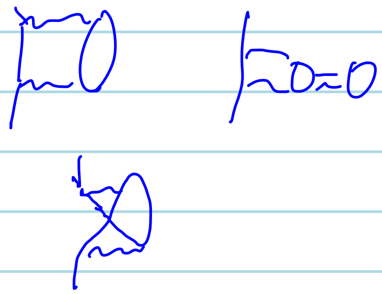
$$i G(1\,2) = \langle T[\psi(1)\ \psi^{\dagger}(2)] \rangle$$

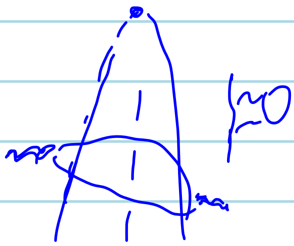
$$\mp i G^{<}(1\,2) = \langle \psi^{\dagger}(2)\ \psi(1) \rangle \qquad i G^{>}(1\,2) = \langle \psi(1) \psi^{\dagger}(2) \rangle$$

DYSON EQ $\quad G = G_0 + G_0 \Sigma G = G_0 + G \Sigma G_0$









$$G_0^{-1} \left(G = G_0 + G_0 \Sigma G \right)$$

$$G_0 G = 1 + \Sigma G$$

KADANOFF-BAYM EQS

$$f(p\,\omega\,X\,T) = \int e^{-ipx} e^{i\omega t} \langle \psi^+(X+\tfrac{x}{2}, T+\tfrac{t}{2})\, \psi(X-\tfrac{x}{2}, T-\tfrac{t}{2}) \rangle \, dx\, dt$$

$$\int dp \int d\omega\, f = n(XT)$$

$$A(p\,\omega)$$

$$\Theta(\mu-\omega)\; \delta(p,\omega)$$

$$\frac{1}{e^{\beta(\omega-\mu)} \pm 1}$$

1 2 H1)

$$G_0^{-1} G^< = \Sigma^+ G^< + \Sigma^< G^-$$

$$i\frac{\partial}{\partial t} + \frac{P_x^2}{2m}$$ DENSITY CAUSALITY

CIH

$$G^< G_0^{-1} = G^< \Sigma^- + G^+ \Sigma^<$$

1 2

$$\int d(x_1 - x_3) \int d(t_1 - t_3)\, e^{-ip(x_1 - x_3)}\, e^{+i\omega(t_1 - t_3)}$$

$$\Sigma(1\,2)\, G(2\,3) \simeq \Sigma(p\,\omega\,X\,T)\, G(p\,\omega\,X\,T)$$

PEAKED IN RELATIVE ARG

$$+\frac{i\hbar}{2}\left(\frac{\partial\Sigma}{\partial X}\frac{\partial G}{\partial p}-\frac{\partial\Sigma}{\partial T}\frac{\partial G}{\partial \omega}-\frac{\partial\Sigma}{\partial p}\frac{\partial G}{\partial X}+\frac{\partial\Sigma}{\partial \omega}\frac{\partial G}{\partial T}\right)$$

$$\parallel$$

$$\frac{i\hbar}{2}\left\{\Sigma\, G\right\}_{PB} + \dots$$

GAIN

$$\left\{ \mathrm{Re}\,(G^{-1})^{+} ,\; -iG^{<}\right\} - \left\{ -i\Sigma^{<} , \mathrm{Re}\, G^{+}\right\} = iG^{>}(-i\Sigma^{<})$$

$$\int d\omega \qquad \delta(\omega-\omega_p) \qquad A= \qquad - (-iG^{<})\, i\Sigma^{>}$$

LOSS

$$\frac{\partial f}{\partial T}+\frac{\partial \omega_p}{\partial p}\frac{\partial f}{\partial X}-\frac{\partial \omega_p}{\partial X}\frac{\partial f}{\partial p}$$

ARGUED

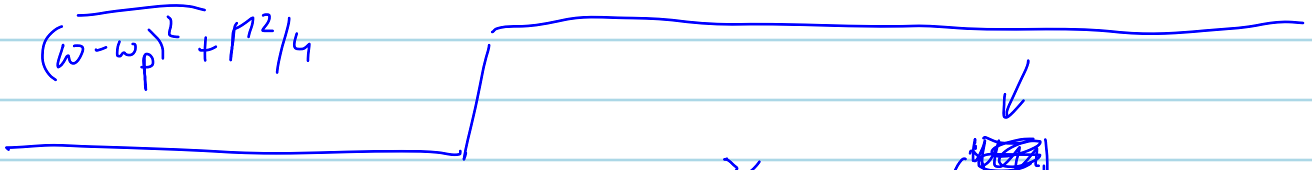
USED IN GIESSEN

DE BROGLIE WLENGTH SHORT

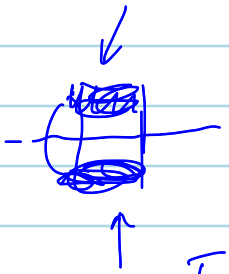
$e^{ip(x_1-x_2)}$ $\quad \Sigma(1,2)$ $\quad$ 1−2 → FAST VARIATION

MACROSCOPIC → $\frac{1+2}{2}$ SLOW VARIATION

$$\frac{1}{(\omega-\omega_p)^2+\Gamma^2/4}$$



$\Sigma^{<}$



BARE NN INTERACTIONS DON'T WORK IN MEDIUM

T-MATRIX IN THE MEDIUM

$$\frac{\partial f}{\partial t} + \frac{\partial \omega_p}{\partial p}\frac{\partial f}{\partial r} - \frac{\partial \omega_p}{\partial r}\frac{\partial f}{\partial p} = I$$

? SOLUTION

TEST-PARTICLE METHOD

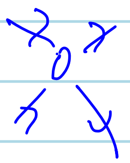
$$f(\bar{r},\bar{p},t) \simeq \frac{1}{N}\sum_i \delta(r-\bar{r}_i(t))\,\delta(p-\bar{p}_i(t))$$

$N = 200 - 5000$ # OF TEST PARTICLE

$$\dot{\bar{r}}_i = \frac{\partial \omega_p}{\partial \bar{p}_i} \qquad \dot{\bar{p}}_i = -\frac{\partial \omega_p}{\partial \bar{r}_i}$$

TEST PTCLES ALSO COLLIDE

$$|\bar{r}_i - \bar{r}_j| < \sigma^{1/2}$$

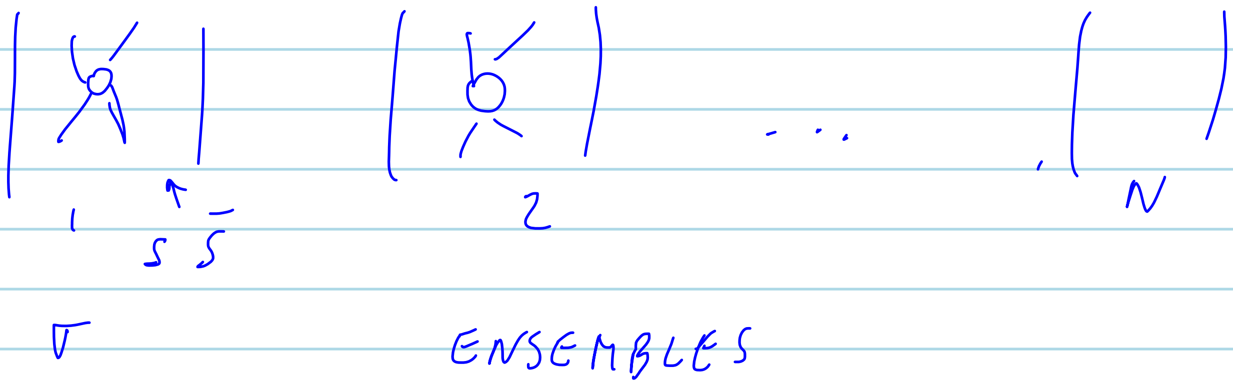


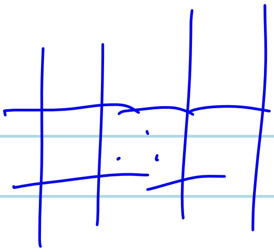
GLOBAL VS

PARALLEL ENSEMBLE

$$\sigma \to \frac{\sigma}{N}$$

$\leftrightarrow \omega_p \leftarrow (1 \pm f) \leftarrow$ ALL ENSEMBLES ARE USED





ANOTHER METHOD
SPACE DIVIDED INTO CELLS
& CALCULATE RATES FOR PROCESSES

DETAILED BALANCE ISSUE

GOOD F/ MULTIBODY COLLISIONS

$$I(\{f_{eq}\}) = 0$$

GAIN

LOSS

$$|\mathcal{M}|^2 \Big[f_1'^{\,eq} f_2'^{\,eq} (1-f_1^{eq})(1-f_2^{eq}) - (1-f_1'^{\,eq})(1-f_2'^{\,eq}) f_1^{eq} f_2^{eq} \Big]$$

$$\delta(p_1+p_2-p_1'-p_2')\,\delta(\omega_1+\omega_2-\omega_1'-\omega_2')$$

$$(1-f_1')(1-f_2') \qquad f_1 f_2 |\mathcal{M}|^2 \left[\frac{f_1'}{1-f_1'} \frac{f_2'}{1-f_2'} \frac{1-f_1}{f_1} \frac{1-f_2}{f_2} - 1 \right]$$

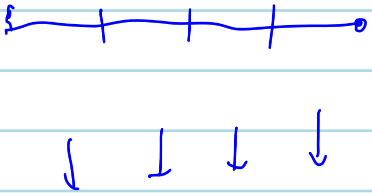
$$\delta(\quad)\,\delta(\quad)$$

$$[\quad] = \exp\left[\log\frac{f_1'}{1-f_1'} + \log\frac{f_2'}{1-f_2'} - \log\frac{f_1}{1-f_1} - \log\frac{f_2}{1-f_2} \right]$$

$$\log \frac{f_1}{1-f_1} = \frac{1}{T}(\gamma \omega_1 - \beta p_1) \Rightarrow f_1 = \frac{1}{\exp\left(\frac{1}{T}(\gamma\omega - \beta p)\right) + 1}$$

$\bar{p} + N \to$ MULTITUDE OF π's

STRING FRAGMENTATION MODELED IN PYTHIA



HADRONS

CUT-OFF $\sqrt{s}$

$$\begin{array}{ccccc} N + N & \to & N^* & + & N^* \\ & & \downarrow & & \downarrow \\ & & N+\pi & & N+\pi \end{array}$$