Bogoljubova transf.

maticový zápis [pos, neg] módů

$$\hat{\Phi} = [u^+ \; u^-] \cdot \begin{bmatrix} \hat{a}_i \\ \hat{a}_i^+ \end{bmatrix} = [v^+ \; v^-] \cdot \begin{bmatrix} \hat{a}_f \\ \hat{a}_f^+ \end{bmatrix}$$

$$[v^+ \; v^-] = [u^+ \; u^-] \cdot \begin{bmatrix} \alpha & \beta^* \\ \beta & \alpha^* \end{bmatrix} \qquad [u^+ \; u^-] = [v^+ \; v^-] \cdot \begin{bmatrix} \alpha^+ & -\beta^{T*} \\ -\beta^T & \alpha^{+*} \end{bmatrix}$$

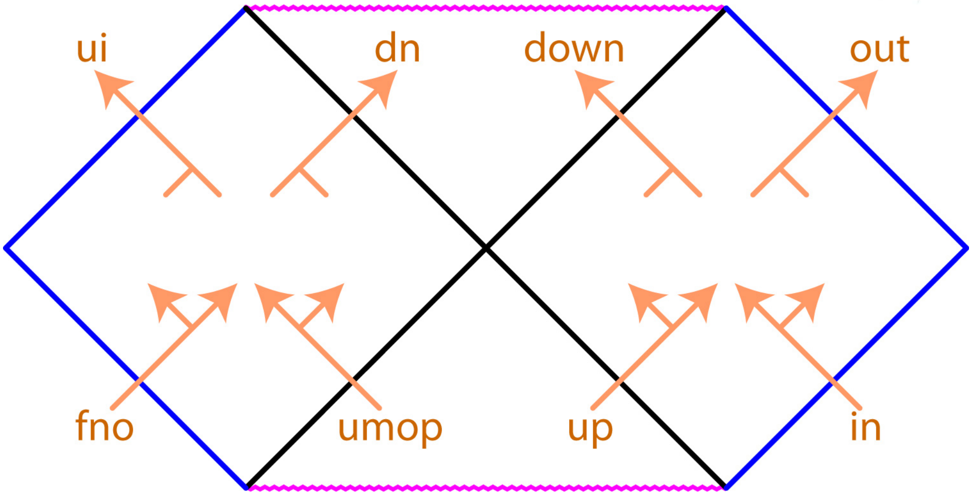
$$\alpha \cdot \alpha^T - \beta \cdot \beta^T = \delta \qquad \beta \alpha^+ = \alpha^* \cdot \beta^T$$

$$V = -\alpha^{-1} \cdot \beta \qquad \Lambda = \beta \cdot \alpha^{-1} \qquad I = \alpha^{-1}$$

$$|i\,vac\rangle = \circ \exp\left(\tfrac{1}{2} \hat{a}_f^+ \cdot V \cdot \hat{a}_f^+\right) |f\,vac\rangle$$

$$\langle f\,vac| = \langle i\,vac| \exp\left(\tfrac{1}{2} \hat{a}_i \cdot \Lambda \cdot \hat{a}_i\right) \circ$$

Boulwarovy módy (LR)



ortonormální báze

	w_q^{ui}	w_q^{dn}	w_q^{down}	w_q^{out}	Σ_f
	w_q^{fno}	w_q^{umop}	w_q^{up}	w_q^{in}	Σ_i
	w_q^{ui}	w_q^{dn}	w_q^{up}	w_q^{in}	Σ_ν
	w_q^{fno}	w_q^{umop}	w_q^{down}	w_q^{out}	Σ_n

rozptyl na křivosti

$$w_q^{in+} = T_q\, w_q^{down+} + R_q\, w_q^{out+} \qquad w_q^{out+} = T_q\, w_q^{up+} + R_q^*\, w_q^{in+}$$

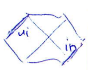
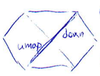
$$w_q^{up+} = T_q^*\, w_q^{out+} - R_q^*\, w_q^{down+} \qquad w_q^{down+} = T_q^*\, w_q^{in+} - R_q\, w_q^{up+}$$

$$w_q^{ui+} = T_q^*\, w_q^{umop+} + R_q^*\, w_q^{fno+} \qquad w_q^{fno+} = T_q^*\, w_q^{dn+} + R_q\, w_q^{ui+}$$

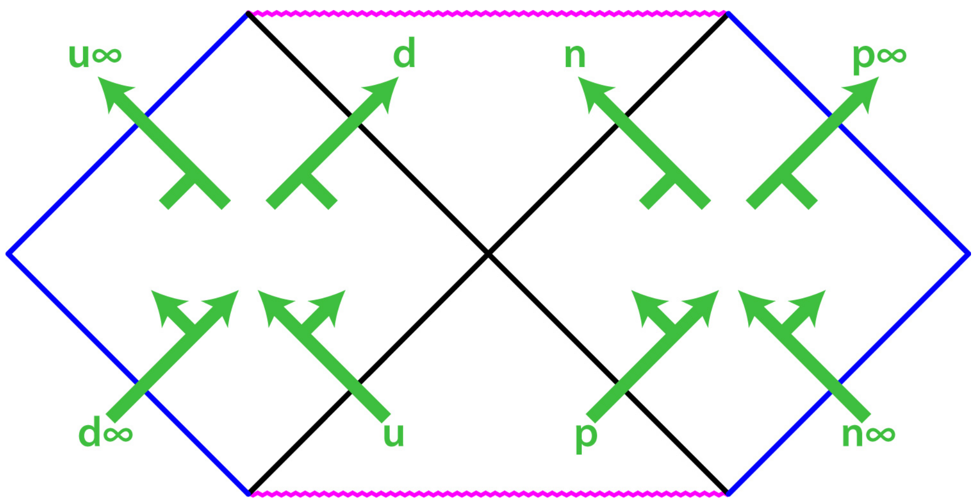
$$w_q^{dn+} = T_q\, w_q^{fno+} - R_q\, w_q^{umop+} \qquad w_q^{umop+} = T_q\, w_q^{ui+} - R_q^*\, w_q^{dn+}$$

Skalární součiny B módů

$$\langle w^B, w^{B'} \rangle_B = -i\, w^{B-} \cdot \partial f \cdot w^{B'+}$$

B \ B'		 dn	up	 umop	down	 fno	out	 ui	in
	dn	1	0	$-R^*$	0	T^*	0	0	0
	up	0	1	0	$-R$	0	T	0	0
	umop	$-R$	0	1	0	0	0	T^*	0
	down	0	$-R^*$	0	1	0	0	0	T
	fno	T	0	0	0	1	0	R^*	0
	out	0	T^*	0	0	0	1	0	R
	ui	0	0	T	0	R	0	1	0
	in	0	0	0	T^*	0	R^*	0	1

Hartle-Hawkingovy módy (HH)



ortonormální báze

	$m_f^{u\infty}$	m_f^{d}	m_f^{n}	$m_f^{p\infty}$	Σ_f
	$m_f^{d\infty}$	m_f^{u}	m_f^{p}	$m_f^{n\infty}$	Σ_i
	$m_f^{u\infty}$	m_f^{d}	m_f^{p}	$m_f^{n\infty}$	Σ_N
	$m_f^{d\infty}$	m_f^{u}	m_f^{n}	$m_f^{p\infty}$	Σ_n

rozptyl na křivosti

$$m_f^{n\infty+} = T_f\, m_f^{n+} + R_f\, m_f^{p\infty+}$$
$$m_f^{p+} = T_f^*\, m_f^{p\infty+} - R_f^*\, m_f^{n+}$$

$$m_f^{u\infty+} = T_f^*\, m_f^{u+} + R_f^*\, m_f^{d\infty+}$$
$$m_f^{d+} = T_f\, m_f^{d\infty+} - R_f\, m_f^{u+}$$

$$m_f^{p\infty+} = T_f\, m_f^{p+} + R_f^*\, m_f^{n\infty+}$$
$$m_f^{n+} = T_f^*\, m_f^{n+} - R_f\, m_f^{p+}$$

$$m_f^{d\infty+} = T_f^*\, m_f^{d+} + R_f\, m_f^{u\infty+}$$
$$m_f^{u+} = T_f\, m_f^{u\infty+} - R_f^*\, m_f^{d+}$$

Skalární součiny HH módů

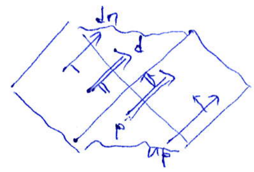
$$\langle m^H, m^{H'} \rangle_{HH} = -i\, m^{H-} \cdot \partial \hat{f} \cdot m^{H'+}$$

H \ H'	d	p	u	n	d∞	p∞	u∞	n∞
d	1	0	$-R^*$	0	T^*	0	0	0
p	0	1	0	$-R$	0	T	0	0
u	$-R$	0	1	0	0	0	T^*	0
n	0	$-R^*$	0	1	0	0	0	T
d∞	T	0	0	0	1	0	R^*	0
p∞	0	T^*	0	0	0	1	0	R
u∞	0	0	T	0	R	0	1	0
n∞	0	0	0	T^*	0	R^*	0	1

Hartle-Hawking módy vs. Boulware módy

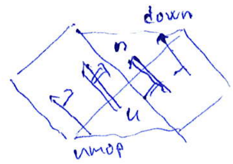
$$m^{d+}_g = C_g w^{dn+}_g + S_g w^{up-}_g \qquad w^{dn+}_g = C_g m^{d+}_g - S_g m^{p-}_g$$

$$m^{p+}_g = C_g w^{up+}_g + S_g w^{dn-}_g \qquad w^{up+}_g = C_g m^{p+}_g - S_g m^{d-}_g$$



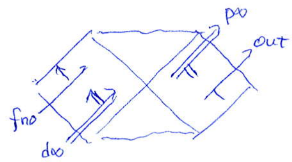
$$m^{n+}_g = C_g w^{down+}_g + S_g w^{umop-}_g \qquad w^{down+}_g = C_g m^{n+}_g - S_g m^{u-}_g$$

$$m^{u+}_g = C_g w^{umop+}_g + S_g w^{down-}_g \qquad w^{umop+}_g = C_g m^{u+}_g - S_g m^{n-}_g$$



$$m^{d\infty+}_g = C_g w^{fno+}_g + S_g w^{out-}_g \qquad w^{fno+}_g = C_g m^{d\infty+}_g - S_g m^{p\infty-}_g$$

$$m^{p\infty+}_g = C_g w^{out+}_g + S_g w^{fno-}_g \qquad w^{out+}_g = C_g m^{p\infty+}_g - S_g m^{d\infty-}_g$$



$$m^{n\infty+}_g = C_g w^{in+}_g + S_g w^{ui-}_g \qquad w^{in+}_g = C_g m^{n\infty+}_g - S_g m^{u\infty-}_g$$

$$m^{u\infty+}_g = C_g w^{ui+}_g + S_g w^{in-}_g \qquad w^{ui+}_g = C_g m^{u\infty+}_g - S_g m^{n\infty-}_g$$