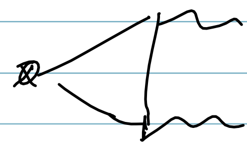
	$Sp(2N)$	$SU(2F)$	$U(1)_R$
Q	$\square$	$\square$	$\frac{F-1-N}{F}$

$$b = 3T(\text{adj}) - 2F$$
$$= 3(2N+2) - 2F$$



$$= 1 \cdot T(\text{adj}) + (R-1)2F = 0$$

$$R-1 = -\frac{(2N+2)}{2F}$$

$$R = \frac{F-1-N}{F}$$

No baryons

	$U(1)_A$	$U(1)_R$
Q	1	$\frac{F-1-N}{F}$
λ	0	1
$\Lambda^{b/2}$	$2F$	0
$Pf(M)$	$2F$	$2(F-1-N)$

$$\epsilon^{i_1 \dots i_{2F}} M_{i_1 i_2} \dots M_{i_{2F-1} i_{2F}}$$

$$W \propto \left(\frac{\Lambda^{b/2}}{Pf(M)} \right)^{\frac{1}{N+1-F}} \quad \text{for } F < N+1$$

$F = N+1$ $Pf(M) = \Lambda^{2(N+1)}$ conf. with χSB

$F = N+2$ $W = Pf(M)$ conf without χSB

(86)

$F \geq N+3$ Duality

	$Sp(2(F-N-2))$	$SU(2F)$	$U(1)_R$
q	$\square$	$\bar{\square}$	$\frac{N+1}{F}$
M	1	$\begin{smallmatrix}\square\\\square\end{smallmatrix}$	$\frac{2(F-1-N)}{F}$

$$W = M_{ij}\,\phi^i \phi^j$$

$SU(F)^3 : 2N$

$-2(F-N-2)$
$2F-4$
$= 2N$

IR FP $\quad \frac{3}{2}(N+1) < F < 3(N+1)$

IR Free $\quad N+3 \leq F \leq \frac{3}{2}(N+1)$

Folklore. Chiral theories are interesting they may break SUSY dynamically

Witten index: Vector-like theory
give masses to al but gauge multiplet
→ pure gauge theory → gaugino condensation

no SUSY breaking
→ take mass terms to zero

→ no SUSY breaking

	$SU(N)$	$SU(N+4)$
T	$\square\!\square$	1
$\overline{Q}$	$\overline{\square}$	$\square$

$W = 0$

↓

	$SO(8)$	$SU(N+4)$
q	$\square$	$\overline{\square}$
p	S	1
$U \sim (\det T)$	1	1
$M \sim \overline{Q} T \overline{Q}$	1	$\square\!\square$

$W = Mqq + Upp$

$SU(N+4)^3$: N | $-8 + N+4+4$

$$\overline{Q}^N \longleftrightarrow q^4 p^2$$

$$\overline{Q}^{N-2n} T^{N-n} W_\alpha^n \longleftrightarrow q^{4+2n} \tilde{W}_\alpha^{2-n}$$

$$\tilde{b} = 3(8-2) - (N+4) - 1$$

$$= 13 - N$$

IR free for $N > 13$

(88)

S-confinement

generalizes $SU(N)$, $N+1$ flavor

$$W = \frac{1}{\Lambda^{2N-1}} \left(\det M - B M \bar{B} \right)$$

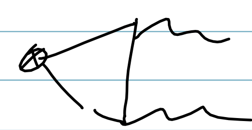
1) no χSB valid description over whole classical moduli space

=> no phase transition
every source can be screened
complimentarity fundamentals SU, Sp
Spinors SO

2) superpotential is generated

=> index constraint

	$U(1)_R$
ϕ_i	q
$\phi_{j \neq i}$	0



$$0 = T(Ad) + (q-1) T(r_i) - \sum_{j \neq i} T(r_j)$$

$$0 = q\, T(r_i) + T(Ad) - \sum_j T(r_j)$$

$R(W) = 2$

$$W \propto \left(\phi_i^{\,T(r_i)} \right)^{\frac{2}{\sum_j T(r_j) - T(Ad)}}$$

$$W \propto \Lambda^3 \left(\prod_i \left(\frac{\phi_i}{\Lambda} \right)^{T(r_i)} \right)^{\frac{2}{\sum_j T(r_j) - T(Ad)}}$$

maybe sum terms since there can be different contractions of gauge indices

holomorphic at origin

$\Rightarrow$ integer power of composite fields

$\Rightarrow$ integer powers of fundamental fields

so unless all $T(r_i)$ have a common divisor

SO $T(\square)=1$
Sp $T(\square)=1$ $\Big\}$ $\sum_j T(r_j) - T(Ad) = 1$ or 2

SU $T(\square)=\frac{1}{2}$ $2\left(\sum_j T(r_j) - T(Ad)\right) = 1$ or 2

Anomaly cancelation Sp Witten anomaly

$2T(r)$ and $A(r)$ are both even or odd

$\sum_i A(r_i) = 0$ even

$$\sum_j T(r_j) - T(Ad) = \begin{cases} 1 & SO, SU \\ 2 & Sp \end{cases}$$

necessary condition / not sufficient

going out moduli space

break to smaller gauge group

decomposes reps → reps + singlets

↓ not s-confining ⇒ original theory not s-confining

↙ s-confining?

→ out in moduli space → another s-confining theory?

ex $SU(4)$ $3\,\boxminus$ $2(\Box + \overline{\Box})$

$\sum_i T(r_i) - 2T(Ad) = 2$

$3(4-2) + 2\cdot 2 - 8 = 6+4-8 = 2$

one $\langle \boxminus \rangle \neq 0$

→ $Sp(4)$ $2\,\boxminus + 4\,\Box$

$2(4-2) + 4 - (4+2) = 2$

↓ two $\langle \boxminus \rangle$

$SU(2)$ $8\,\Box$ IR FP

not-s-confining

→ $\langle \Box \rangle \neq 0$, $\langle \overline{\Box} \rangle \neq 0$

$SU(3) + 4(\Box + \overline{\Box})$ is s-confining

Ex

	$SU(2N+1)$	$SU(2N+1)$	$SU(4)$	$3\ U(1)$s
A	$\boxminus$	1	1	
$\overline{Q}$	$\overline{\Box}$	$\Box$	1	
Q	$\Box$	1	$\Box$	

confined description

	$SU(2N+1)$	$SU(4)$
$Q\overline{Q}$	$\Box$	$\Box$
$A\overline{Q}^2$	$\boxminus$	1
$A^N Q$	1	$\Box$
$A^{N-1} Q^3$	1	$\overline{\Box}$
$\overline{Q}^{2N+1}$	1	1

$$W = \frac{1}{\Lambda^{2N}}\Big((A^N Q)(Q\overline{Q})^3 (A\overline{Q}^2)^{N-1} + (A^{N-1}Q^3)(Q\overline{Q})(A\overline{Q}^2) + (\overline{Q}^{2N+1})(A^N Q)(A^{N-1}Q^3) \Big)$$

eqs. of motion reproduce the classical constraints

integrating out a flavor gives
confinement with χSB