

# **ARTS3049**

@]hYfUfm5b]a U`gž'A cbghYfg'UbX'A UVX]bYg

HYfa 'C bY''##'&\$&%

### 7ci fgY'Cj Yfj ]Yk

#### GHJZZ7cbHJWh8YHJ]`g

#### 7cbj Ybcfg

B Ua Y	9a U]`	5j U]`UV]`]lm	@cWUhjcb	D\cbY
G][] <sup>·</sup> >chh_UbXh	g"1ch_UbXh4 i bgk "YXi "Ui	6miUddc]bha Ybh	Fcca ′′ ‱	-',)'(,)*

#### GWXcc~7cbhJWh~abZcfa Uhlcb

GWXcc`cZh\Y'5fhg'UbX'AYX]U

Fcca " %&ž@YjY`" žFcVYfhK YVghYf'6i]X]b['f) %(Ł

D\cbY.'f\$&E'-',)'(,)\*

9a U]` gUa 4 i bgk "YXi "Ui

K YVg]hY. k k k "Ufhg"i bgk "YXi "Ui #gUa

 $\label{eq:hamiltonian} $$HY'GW.cc``cZh,Y'5ftg'UbX'AYX]U'k ci`X``]_Y'tc'FYgdYWM\cong \cong m5W_bck``YX[Y'th,Y'HfUX]tjcbU``7i gtcX]Ubg\cong hY'6YXY[U'``fPYbg]b[tcb'WJa di g\cong \cong \cong \cong mUbX'5fti/'8Yg][b'7Ua di gYg\cong \cong \con$ 

### 7ci fgY 8YHJ] g

### 7 fYX]hDc]bhg\*\*

#### Gi a a UfmcZh\Y 7ci fgY

K ]XYgdfYUX ]b h\Y \i a Ub]hYg Uhh\Y a ca Ybh]g U fYh\]b\_]b[ cZk \Uh]ha YUbg hc VY \i a Ub" \dot h\]g Wci fgY mci k ]```cc\_'Uh\ck '`]hYfUhi fY UbX Z]`a i gY h\Y bcb\i a Ub gi V YWlj ]mcZUb]a U`gža cbghYfg UbX a UW\]bYg hc g\UdY ci f i bXYfghUbX]b[ cZh\Y \i a Ub" 6mYl Ua ]b]b[ 'h\Y W\Ub[ ]b[ 'dfYgYbhUh]cb cZUb]a U`gža cbghYfg UbX a UW\]bYg ]b U'fUb[ Y`cZhYl hg Zca 'h\Y gYj YbhYbh\ W\bh fmh\fci [ \hc h\Y VY[ ]bb]b[ 'cZh\Y 'h\ Ybm Z]fghW\bh fm\fci [ \hc h\Y VY[ ]bb]b[ 'cZh\Y 'h\ Ybm Z]fghW\bh fm\fun fci [ \hc h\Y VY[ ]bb]b[ 'cZh\Y 'h\ Ybm Z]fghW\bh fm\fun fci k ]``]bj Ygh][ UhY \ck 'UYgh\Yh]WdfUW]Wg gi W\ 'Ug`]hYfUhi fY 'UbX Z]`a 'Yl hYbX UbX 'hYghci f gma dUh\Yh]W]a U[ ]bUh]cb 'VmU`ck ]b[ 'i g hc ]b\UV]hgi VYWhdcg]h]cbg 'h\Uhk Y 'UfY 'bcfa U`mi bUV`Y 'hc ]b\UV]h' \dot h'Jg 'Wci fgYžmci 'k ]``XYj Y`cd 'U'gYbgY 'cZh\Y 'Yh\]WU`zgcW]U'zdc`]h]WU``UbX'd\]`cgcd\]WU` j U'i Y`cZ`]hYfUhi fY 'UbX'Z]`a "

#### 7 ci fgY @YUfb]b[ Ci hMca Yg

%" 91 Ua ]bY \ck 'h\Y bch]cbg'cZh\Y \i a Ub'UbX'h\Y bcb\i a Ub'Ub]a U``\Uj Y XYj Y`cdYX`\]ghcf]\W\`m &" 8Yj Y`cd'h\YcfYh]\W\``Uf[ i a Ybhg'UVci hh\Y'i gY cZh\Y bch]cbg'cZh\Y \i a Ub'UbX'h\Y bcb\i a Ub']b `]hYfUhi fY UbX'Z|`a

' "5fh]W\`UhY`\ck`Ub]a U`gža cbghYfg`UbX`a UW\]bYg`Z bWf]cb`Ug`ch\Yfg`hc`\i a Ub`gY`j Yg`]b``]hYfUhi fY UbX`Zl`a

#### HYUWX]b[ 'GhfUhY[]Yg'

H\Y^YWi fYg'k]```fY\YUfgY'h\Y'dfYgYbhUfjcb'cZ]XYUg'UbX'Uf[i a Ybh]b`fY`Ufjcb'hc'\]ghcf]W\``UbX'h\YcfYh]W\` WcbWdfjcbg'cZh\Y'fc`Y'cZUb]a U`gža cbghYfg'UbX'a UW\]bYg']b``]hYfUhi fY"'H\Y^YWi fYg'k]```VY']bhYfUWfj Yž ]bWi X]b['fja Y'Zcf'mci f'ei Ygfjcbgž'UbX'mci 'k]``XYj Y`cd'h\Y']bhY``YWi U``Wca a i b]lmcZh\Y'Wci fgY"'H\Y gYa]bUfg'fYei]fY'XYfU]`YX'dfYdUfUfjcbžk\]W\'Zcfa g'h\Y'VUg]g'Zcf'\][\``Yj Y``X]gWi gg]cb"'GYa]bUfg'k]`` ]bWi XY'Vch\'k\c`Y'[fci d'X]gWi gg]cbg'UbX'ga U``[fci d'X]gWi gg]cbg"'H\Y'cb`]bY'gi ddcfhk]``]bWi XY'U fYdcg]lcfmcZWci fgY']bZcfa Ufjcb"

### 5ggYgga Ybh

Dfc YWiA i gY fa i gY"\i "YXi E'UbX 'ghcf'flghcf"cf[ E'UfY YI WY``YbhfYgYUfW\ XUHUVUgYg 'Zcf'mci f UggYgga Ybhg"

#### 5ggYgga Ybh'HUg\_g

5ggYgga Ybh'tUg_	K Y][\h	8iY'8UHY	Gh XYbh@YUfb]b[ Ci hWca Yg 5ggYggYX
@cb[ '9ggUm'	* \$1	&*#\$(#&\$&%`%%\$\$`DA	%ž'&ž''
F YgYUfVX '91 YfWjgY'	(\$1	%* #\$' #&\$&%`%% \$\$`DA	%ž'&ž''

#### 5ggYgga Ybh'8YHJ]`g

5ggYgga Ybh% @cb[ '9ggUm

@Yb[h\. %) \$\$ k cfXg

8 YW] g.

&) \$\$'k cfX'YggUm''

: YYXVUW\_'dfcj ]XYX'j ]U'Hi fb]hjb"

#### 5XX]h]cbU`XYhU]`g.

 $\label{eq:hamiltonian} $$H^{g'}g'U'&) $$!k cfX'YggUm\check{z}Xi Y''%da \check{z}A cbXUm\check{z}'&^h\ '5df]'''D'YUgY'Wcbgi `hh\Y'YggUmei Ygh]cbg'cb A ccX'Y''$ 

Hi fb]hjb gYhjb[. `H\]g Ugg][ ba Ybh]g gi Va ]hhYX h\fci [\`Hi fb]hjb UbX gh XYbhg Xc bchgYY Hi fb]hjb g]a ]`Uf]hmfYdcfhg"

5ggYgga Ybh'& FYgYUfW '9I YfW]gY

@Yb[h\. \*\%\$\$\*k cfXg

8 YHJ] g.

5 '%\$\$\$!k cfX`YI YfW]gY`dfYdUf]b[ 'ghi XYbhg`Zcf`h\Y``cb[ 'YggUm''Ghi XYbhg`k ]```VY`Ug\_YX`hc`fYgYUfWk gYWcbXUfmgci fWrg`UbX`]XYbh]ZmU`ei Ygh]cb`Ya Yf[ ]b[ 'Zfca 'h\cgY'gci fWrg"

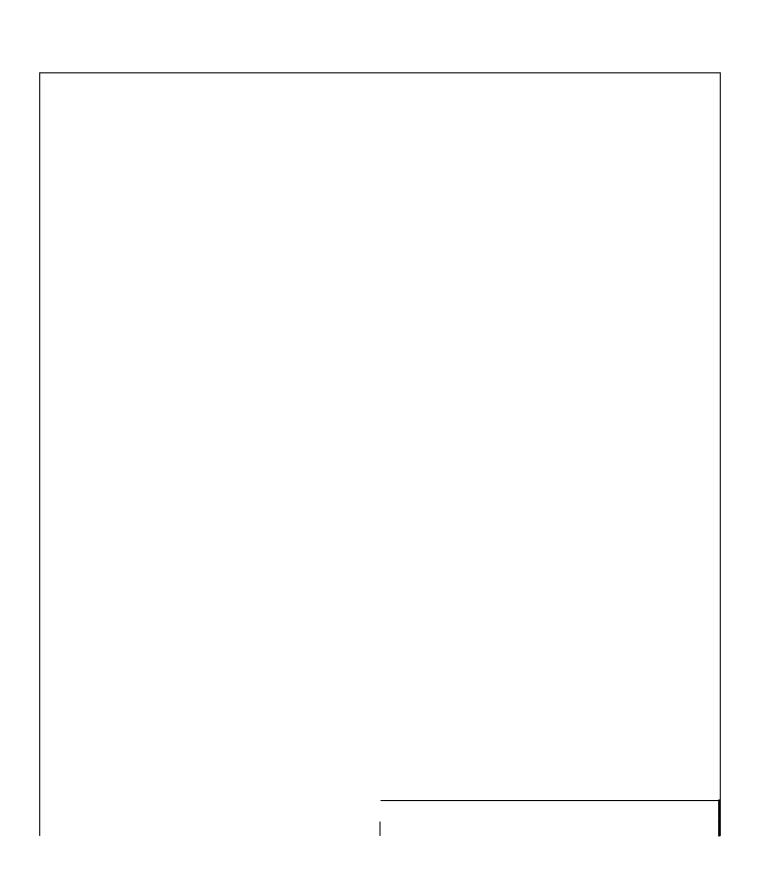
: YYXVUW\_'dfcj ]XYX'j ]U'Hi fb]hjb"

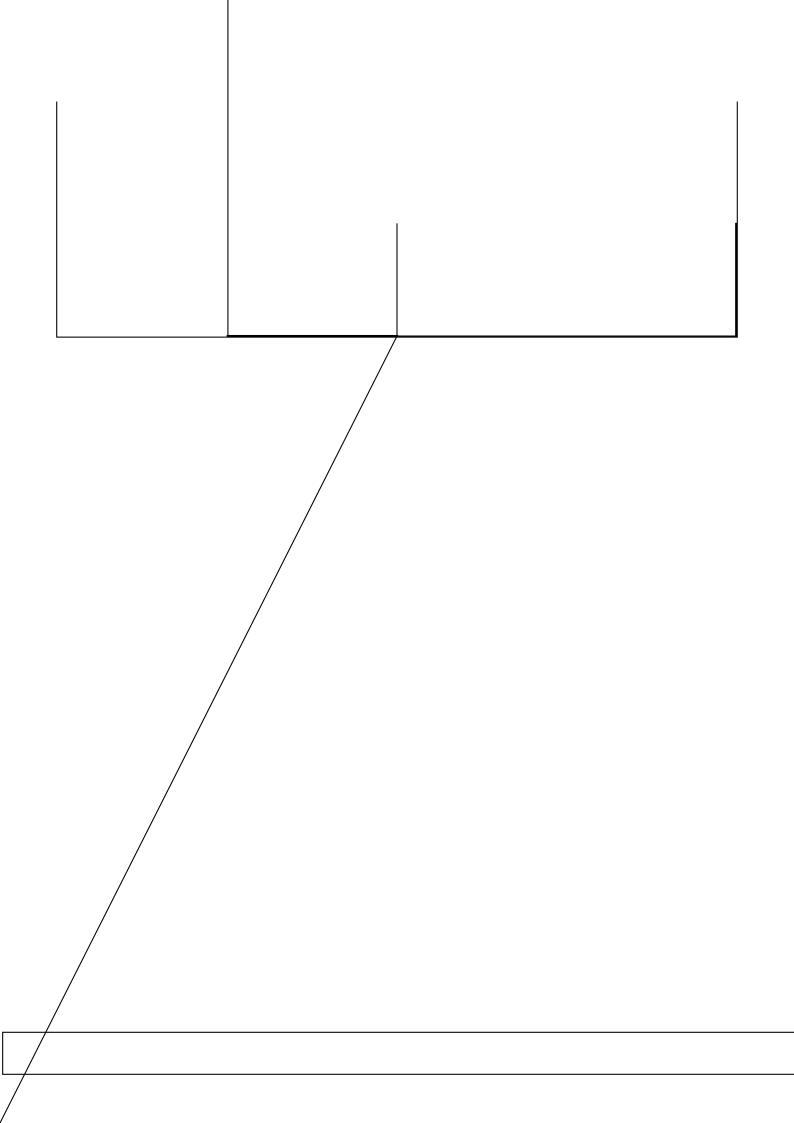
#### 5XX]h]cbU`XYhU]`g.

 $\label{thm:condition} $$ Mci 'UfY'YI dYWYX'hc'XfUk 'cb'gca Y'gYWcbXUfm'Wf]hJWU'`gci fW'g']b`mci f'Ubgk Yf''`H\]g'a ][ \h']bWi XY gYWcbXUfm'Wf]hJWJga 'cb'? UZ_U'g'ghcfmcf'h\Y'Wf]hJWU'`a UhYfJU'`cb'Ubh\fcdca cfd\]ga 'UbX'h\Y'[ fchYgei Y k \]W\'k Y'\Uj Y'X]gW ggYX']b''YWh fYg'UbX'gYa ]bUfg''$ 

Gi Va ]gg]cb bchYg. D`YUgY gYY a ccX`Y ZcfXYhU]`g

 $\label{thm:limit} \begin{tabular}{ll} Hi & fb \end{tabular} $$ h' \end{tabular} $$ h$ 





### FYgci fWfg

#### DfYgWf]VYX F Ygci fWYg

Df]a UfmihYI hg

 $\label{local-control} \text{H}^gY'\text{h}^g'\text{U}$ 

>c\b'6Yf[Yfž'3Tagf>aa][Yfb'ccagVifmL

>cbUh\Ub'Gk]Zhž'9g^{hWdeFdShWefBcfhcb'7f]hJWU`'9X]hJcbl

<""; ""K Y``gžFZW;e'S` V aX6 aUfad? adW\$g

=`U\`FYnU`BcifVU\_\g\ž'\8Y\ia Ub]n]b[`FcVchg""`DaTaf8gfgdWef7Ua Vf]X[Yž'A UggUW\igYhhg.`A  $\pm$ I'DfYggž&\$%  $\pm$  '(-!\*("'

### FYWca a YbXYX FYgci fWfg

: i fh\Yf^fYWca a YbXYX^fYUX]b[

### Gi Va ]gg]cb cZ5ggYgga YbhHUg\_g

### Hi fb]h]b Gi Va ]gg]cb

Image: Ybwei bhyfu'dfcv'ya k \yb'uhhya dhjb[ 'hc'gi va ]hmci f'Ugg][ ba Ybhh\fci [ \ 'Hi fb]h]bž'd'YUgY

Hy'Yd\cby'9| hy'fbu''Gi ddcfhcb'-', ) '' ' ' %cf'Ya U]''h\Ya 'cb'Y! hy'fbu'hy'hgi ddcfh4 i bgk "YXi "Ui "''Gi ddcfh
\ci fg'UfY', .\$\$Ua '-'%\$.\$\$da 'cb'k YY\_XUmg'UbX'-.\$\$Ua '-').\$\$da 'cb'k YY\_YbXg'fl \*) 'XUmg'U'mYUft'''=Z'mci
UfY'i bUV'Y'hc'gi va ]hmci f'Ugg][ ba YbhXi Y'hc'U'ZJi 'hk ]h\ 'Hi fb]h]b'mci 'a Um'Udd'mZcf'Ub'Y! hy'bg]cbž'Vi hmci
a i ghfYhJ]b'mci f'h]W\_Yhbi a VYf'Zfca '9! hy'fbU''Gi ddcfhfU'cb[ 'k ]h\ 'Ubmch\Yf'fy'Yj UbhXcW a Ybhgt'hc
]bWi XY'Ug'Yj ]XYbW' hc'gi ddcfhmci f'Y! hy'bg]cb'Udd']WUh]cb"'=Zmci 'Ya U]''9! hy'fbU''Gi ddcfhmci 'k ]'`
Ui hca Uh]WJ'`mfYW']j Y'U'h]W\_Yhbi a VYfZ'Vi h]Zmci 'hY'Yd\cbY'mci 'k ]``bYYX'hc'gdYW]Z]WJ'`mUg\_'Zcf'cbY''
Hi fb]h]b'U'gc'dfcj ]XYg'i dXUhy'g'cb'h\Y]f'gmghYa 'ghUh' g'cb'Hk]hyf''

; YbYfU`mž'UggYgga YbhiHug\_g'a i ghVY'gi Va ]hhYX'Y`YVWfcb]\WJ``mij ]U'Y]h\Yf'Hi fb]h]b'cf'U'A ccX`Y Ugg][ ba Ybh''=b']bgHJb\W'g'k \YfY'h\]g']g'bchdcgg]V`Yž']hk ]```VY'gHJhYX'cb'mci f'\\circ i fgY'g'A ccX`Y'g]hY'k ]h\U`hYfbUh]j Y'gi Va ]gg]cb'XYHJ]`g"

cfi]bZcfa Uhjcbicbi\ckihcigi Va ]hUgg][ ba Ybhgicbi]bYij ]UiA ccXiY.i\hdg.#gh XYbhi bgk "YXi "Ui #\ck! gi Va ]hUgg][ ba Ybha ccXiY

## 5 WUXYa ]W<cbYghmUbX D`U[]Uf]ga

D`U[]Uf]ga i]gii g]b[ih\Yik cfXgicfi]XYUgicZch\YfgiUbXidfYgYbh]b[ih\Ya iUgimci fick b"i=hWJbihU\_Yia Ubm Zcfa gžZfca iXYi]VYfUhYiWXYUh]b[ihciUWW]XYbhU`mWcdm]b[iZfca iUigci fWYik]h\ci hiUW\_bck iYX[Ya Ybh'

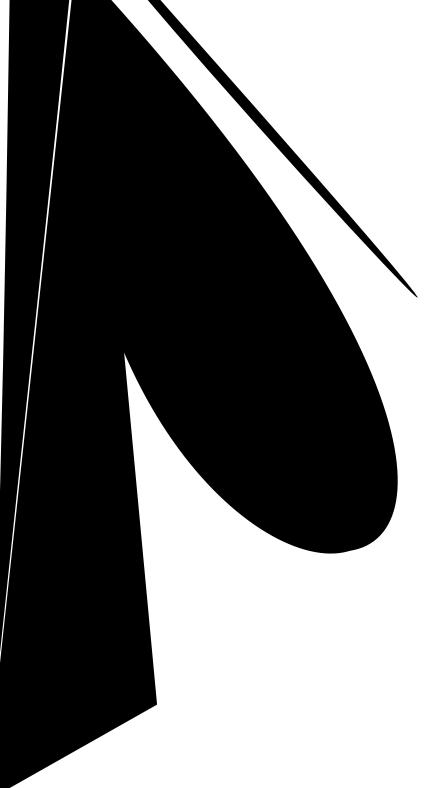
IBGK [fcidg'd'U[]Uf]ga ]bhc'h\Y'Zc``ck]b['WUhY[cf]Yg.

## XYa]W±bZcfaUh]cb

gYbhJU``gh XYbh`]bZcfa UhJcb`fY`UhJb[`hc.

- fyei yghg Zcf yl hybg]cb/
- `UhY`gi Va ]gg]cbg`[ i ]XY`]bYg/
- fYj ]Yk 'cZa Uf\_g/ BGK '<YU'th'UbX'GUZYmidc`]W]Yg/
  - la]bUh]cb'dfcWXifYg/

\``Wcbg]XYfUh]cb`]b`h\Y`Yj YbhcZ]``bYgg`cf`a ]gUXj Ybh fY/



ah XYbhilbž YUMblinc.