

# **ARTS3062**

7]bYa UhWH\]b\_]b[

HYfa 'Hk c''#'&\$&%

### 7ci fgY'Cj Yfj ]Yk

#### GHJZ:7cbHJWh8YHJ]`g

#### 7cbj Ybcfg

B Ua Y	9a U]`	5j U]`UV]`] <b>m</b>	@cWUh]cb	D\cbY
@jgU`HfU\U]f	@'rfU∖U]f4 i bgk "YXi "Ui	,	,	-',))\$‰ Vi hVYghhc Ya U]`

#### GWkcc~7cbhJWh~abZcfa Uh]cb

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

D\cbY. 'f\$&Ł'-',) '(,) \*

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

K YVq]hY. k k k "Ufhq"i bak "YXi "Ui #qUa

 $\label{eq:hamiltonian} $$HY'GWCC``cZhY'5ftg'UbX'AYX]U'kci`X``]_Y'tc'FYgdYWM\cong \cong m5W_bck`YX[Y'h\Y'HfUX]tjcbU``7igtcX]Ubg\cong h\Y'6YXY[U'`fPYbg]b[hcb'WJadig\cong ix', UX][U'`fP]hmUbX'5fti/'8Yg][b'7UadigYg\cong iybUx't\Y'B[ibbUkU`dYcd'Y'fbigffU`]Ub'8YZYbW': cf\w'5\\\XYami]b'7Ub\YffU\cozh\Y'`UbXg'k\YfY'YUW\\WJadig'cZIBGK']g`c\\WJhYX''$ 

### 7ci fgY 8YHJ] g

7 fYX]hDc]bhg\*\*

Gi a a UfmcZh\Y 7ci fgY

H\Y'ZJa ci g'&\$h\ 7 Ybhi fmd\]cgcd\Yf'; ]`Yg'8 Y`Yi nY'k fchY`]b`\]g'Vcc g'cb'WbYa U'h\Uh']h]g'bch gi ZJWJYbhhc Wca dufy h\y [ fYuhX]fYWcfg cZWJbYa u k Jh\ du]bhYfgž ufWX]hYWg cf Yj Yb a i gJWJubg "H\ym a i ghVY'Wca dufYX'hc'h\]b\_Yfg'''6i hk\UhXcYg']ha YUb'hc'h\]b\_'W]bYa Uh]WU`m3' +b'h\Y'k U\_Y'cZh\Y'XYW]bY cZZja h\YcfmUg'h\Y'i b]Zmjb[ a Yh\cXc`c[ mcZh\Y'X]gWjd`]bY'cZZja 'ghi X]Yg'UbX'h\Y'Ya Yf[ YbWY'cZZja! d\]`cgcd\mUg`cbY`cZgYj YfU``bYk `UddfcUWXYgž'h\]g`Wci fgY`]XYbhJZJYg`h\Y`ei YghJcb`cZh\Y`bUh fY`cZZJ`a 'g thci[\hug'U'WcbWfb'th\uhXuhYg'VUW\_hc'th\Y']bWfdh]cb'cZWJbYa U": cW g]b['cb'th\Y'\_]bXg'cZ'th]b\_]b[' i bXYftU\_Yb Vmgca Y cZh\Y '[ fYUhX]fYWcfg']b h\Y \]ghcfmcZWbYa U—]bWi X]b[ k cf\_Vm9]gYbghY]bž 7\Ud`]bž<]h\\\\\\<u>Z</u>`BfYmYfž`K\_Y``Ygž`F cggY``]b]ž`G]f\_ž`?i\Vf]\\<u>Z</u>`HUf\_cj\_g\_mž`J cb`Hf]Yfž`UbX`A\_U`]\\\_—h\Y. Wei fgY'k ]```]blfcXi WY'mci 'hc'h\Y'X]j Yfg]mmcZWebhYa defUfmUddfcUV\\Yg'hc'h\Y'ei YghJcb'cZWbYa UhJW h\]b\_]b[ fdgm\\\cUbU`mf]\\\\\c[b]hj ]gh\(\circ\gYa ]ch]\\\\\\circ\gCd\ **† † † q**Y ·

### 5ggYgga Ybh

GYY'A ccX'Y'Zcf'[YbYfU`'UggYgga Ybh]bZcfa Uh]cb

#### 5ggYgga Ybh HUg\_g

5ggYgga Ybh'hUg_	K Y][\h	8i Y'8UHY	Gh XYbh@YUfb]b[ Ci hWca Yg 5ggYggYX
7 c``UVcfUhjj Y`hi hcf]U` dfYgYbhUhjcb`UbX`fYUX]b[ YI YfWjgY`	(\$1	gi a a UfmiXi YʻcbYʻk YY_ʻUZhYf ZUWjʻ]hUhjcb	%ž &
F YgYUfVX '9ggUm'	*\$1	%\$#\$, #&\$&\$`\$).\$\$`DA	%ž'&ž''

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

5ggYgga Ybh'% '7c``UVcfUhjj Y'hi hcf]U`'dfYgYbhUhjcb''UbX'fYUX]b[ 'Yl YfWjgY

Ghufh Xuhy. h\fci [\ci hhyfa

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

8YHJ]`g.

&`\cif`h hcf]U``ZUWj`]hUhjcb`Ž`%) \$\$`k cfX`gi Va ]gg]cb`cZgi a a UfmcZfY`Yj UbhVcc\_`W\UdhYf"

Gh XYbhg fYVN] Y ZYYXVUW\_j ]U Hi fb]h]b Zcf ZJW] hUh]cb UbX fYUX]b[ YI YfN]gYg"

Hi fb]hjb gYhjb[. `H\]g Ugg][ ba Ybh]g gi Va ]hhYX h\fci [\`Hi fb]hjb UbX ghi XYbhg WUb gYY Hi fb]hjb g]a ]`Uf]hm fYdcfhg"

5ggYgga Ybh& FYgYUfVX 9ggUm

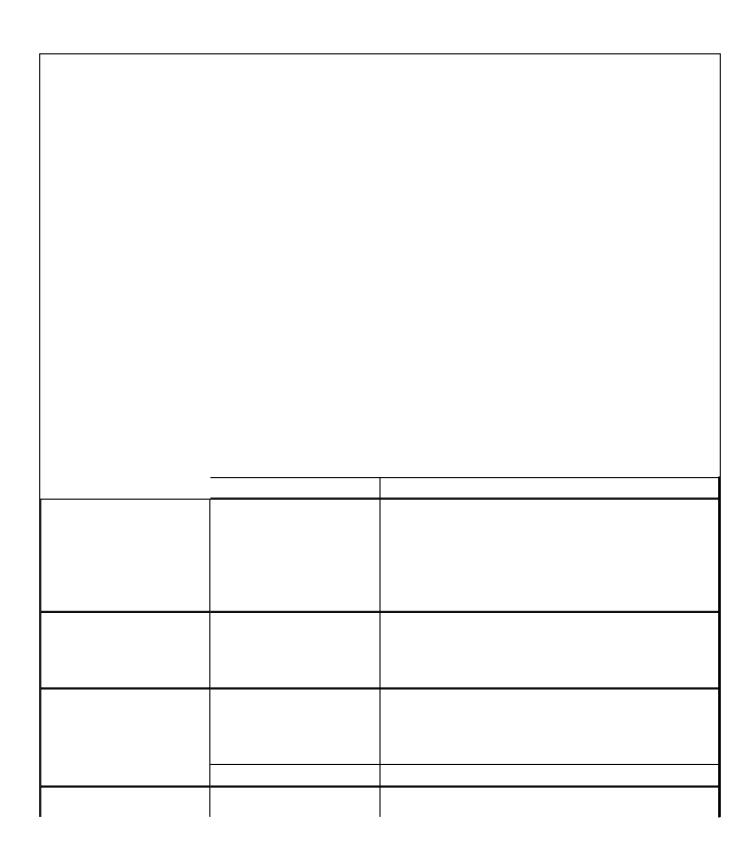
@Yb[ h\. '&) \$\$ k cfXg

8 YHJ]`g.

&) \$\$`k cfXg"`H\]g`]g`h\Y`Z|bU``UggYgga Ybh'hUg\_"

Ghi XYbhg fYWr]j Y ZYYXVUW\_j ]U Hi fb]h]b"

 $\label{thm:limit} \begin{tabular}{ll} Hi fb]h]b gYH]b[. Hi]g Ugg][ba Ybh]g gi Va]hYX hi fci [in Hi fb]h]b UbX ghi XYbhg WUb gYY Hi fb]h]b g]a] Uf]hm fYdcfhg"$ 



5i[igh	GWfYYb]b[.:HYffYbWY'A U`]W_žH\Y'H\]b'FYX
	@]bY`f% - , Łž'%+\$`a ]bi hYg

## Fygci fWyg

DfYgWf]VYX F Ygci fWYg

GYY'A ccX`Y'Zcf'Yl dYWYX'fYgci fWyg

FYWca a YbXYX FYgci fWYg

GYY'A ccX'Y'Zcf'fYWca a YbXYX'fYgci fWYg

7ci fgY '9j U`i Uh]cb 'UbX '8Yj Y`cda Ybh

GYY'A ccX`Y'Zcf']bZcfa Uh]cb'cb'Wci fgY'Yj U`i Uh]cb'UbX'XYj Y`cda Ybh

### 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 UmUdd'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.

• i bXYfgHJbX'mci f'f][\hg'UbX'fYgdcbg]V]`]h]Yg'Ug'U'gh XYbh'Uhil BGK

## 5WUXYa]W±bZcfaUhjcb

: cf'YggYbhJU`ghi XYbh]bZcfa UhJcb'fY`UhJb['hc.

• fYei Yghg Zcf Yl hYbg]cb/