

ARTS3021

7 fYUhjj Y'K f]hjb['=bhYfbg\]d

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

7ci fgY'Cj Yfj]Yk

Ghuzz 7 cbhuWh8 Yhu]`g

'7cbj Ybcfg'

BUa Y	9a U]`	5j U]`UV]`]m	@cWJhjcb	D\cbY
9a a Uʻ>UbY	Yaa U"^UbY4 i bgk "YXi "Ui	-	‰) ž@YjY``%ž FcVYfh KYVghYf	

GWkcc~7cbhJWh~abZcfa Uh]cb

Fcca " &ž`Yj Y`" FcVYfhK YVghYf`6i]`X]b[

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

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

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

 $\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'5fth/'8Yg][b'7UadigYg\cong iybX't\Y'B[ibbUkU`dYcd'Y'fbigffU`]Ub'8YZYbW': cf\w'5\\\XYami]b'7Ub\YffU\cozh\Y'`UbXg'k\YfY'YUW\w'Uadig'cZl\BGK']g`c\\WJhYX''$

7ci fgY 8YHJ] g

7 fYX]hDc]bhg**

Giaa UfmcZh\Y 7ci fgY

GiVYWh5fYU.5dWSf[hWId[f[Y]

H\]g`Wci fgY`dfcj]XYg`mci `k]h\`Ub`cddcfh b]lmhc`i bXYffU_Y`k cf_!]bhY[fUhYX``YUfb]b[`UbX`[U]b`]bXi ghfm YI dYf]YbWY`k]h\`U`\cghcf[Ub]gUh]cb`WcgY`mfY`UhYX`hc`mci f`A U`cf`]b`7 fYUh]j Y`K f]h]b["'Mci `a Um'U`gc`Udd`m hc`k cf_`cb`UhHUW\a Ybhcb`Ub`UWUXYa]WfYgYUfW\`dfc`YWhcf`k cf_`]b`Ub`YX]hcf]U``fc`Y`Zcf`Ub`UWUXYa]W 'ci fbU`"`\\YU\`mž'mci `k]``i bXYfhU_Y`Ub`]bhYfbg\]d`UZhYf`mci `\Uj Y`Wca d`YhYX`%') `mYUfg`cZZ\``!h]a Y`ghi Xmfcf Yei]j U`YbhL'UbX`Wca d`YhYX`U`a]b]a i a `cZ% `I C 7 `]b`h\Y`A U`cf"`5hh\Y`YbX`cZh\Y`]bhYfbg\]d`mci `k]`` dfcj]XY`U`gi a a Uh]j Y`fYdcfhcZmci f`YI dYf]YbWYg`UbX`k cf_`YI Ua d`Yg`Wca d`YhYX`Xi f]b[`h\Y`]bhYfbg\]d"

 $H\Y']bhYfbg\]d'fYei]fYg'U'hchU``Wca a]ha YbhcZ%$$!\%) $`\ci fg'cZk cf_'k]h\'U'\cghcf[Ub]gUh]cb'UbX'a Umbcfa U``mVY'hU_Yb']b'']fghz'gYWcbX'cf'gi a a Yf'gYa YghYf'' <math>=$ bhYfbg\]d'cddcfhi b]hJYg'UfY'UXj YfhJgYX'j]U'h\Y

5ggYgga Ybh

H\]gʻgi VYWfi]gʻi b[fUXYXʻgcʻUʻdUggʻ]gʻXYdYbXYbhcbʻGUfi]gZJWfcfmfGMzʻcfʻI bgUfi]gZJWfcfmfI @zʻ]bʻa YYfi]b[h\Y`Wci fgY`fYei]fYa Ybfg"ʻ5bʻGM[fUXY`k]``bchUZYWfmci f`kY][\hYX`Uj YfU[Y`a Uf_`fK 5A z`Vi hUʻ: @'[fUXY k]``"

7 ci fgY fYei]fYa Ybhg]bWi XY.

• 7 ca d`Yh]cb'cZU'a]b]a i a 'cZ%\$\$'\ci fg'cZd`UWa Ybh

•

cZh\Y'Wta V]bYX'hchU``cZ%) \$\$!&) \$\$`k cfXg`Zcf`Vch\`UggYgga Ybh'Wta dcbYbhg"; fUX]b[`k]```VY GUh]gZJWhcfm# bgUh]gZJWhcfmiUbX'gca Y'gi a a Uh]j Y'ZYYXVUW_ik]```VY'dfcj]XYX"

Gi Va |gg|cb cZ5ggYgga YbhHUg_g

Gi Va]gg]cb cZ5ggYgga YbhHUg_g

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

#mci 'YbWci bhYf'U'dfcV'Ya 'k \Yb'UhYa dhJb['rc'gi Va]hmci f'Ugg][ba YbhNhfci [\'Hi fb]hJbž'd'YUgY
hY'Yd\cbY'9I hYfbU'Gi ddcfhcb'-',) '' ' ' %cfYa U] 'h\Ya 'cb'YI hYfbU'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'f1 *) 'XUmg'U'mYUft'' #c'ii
UfY'i bUV'Y 'rc'gi Va]hmci f'Ugg][ba YbhXi Y 'rc'U'ZJi 'hk]h\ 'Hi fb]hJb 'mci 'a Um'Udd'mZcf'Ub'YI hYbg]cbž'Vi hmci
a i ghfYhJ]b 'mci f'hJW_Yhbi a VYf'Zfca '9I hYfbU''Gi ddcfhfU'cb['k]h\ 'Ubmch\Yf'fY'Yj UbhXcW a Ybhgt'hc
]bWi XY'Ug'Yj]XYbWY 'rc'gi ddcfhmci f'YI hYbg]cb'Udd']WUh]cb'' #mci 'Ya U]''9I hYfbU''Gi ddcfhmci 'k]'`
Ui hca UhJWJ'`mfYWY]j Y'U'hJW_Yhbi a VYfž'Vi h]Zmci 'hY'Yd\cbY'mci 'k]'``bYYX'hc'gdYWJZJWJ'`mUg_'Zcf'cbY''
Hi fb]hJb'U'gc'dfcj]XYg'i dXUhYg'cb'h\Y]f'gmghYa 'ghUh' g'cb'Hk]hYf"

; YbYfU``mž'UggYgga YbhiHug_g'a i ghVY'gi Va]hhYX'Y`YVWfcb]\W)``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'\\ci fgY'g'A ccX`Y'g]hY'k]h\ U`hYfbUh]j Y'gi Va]gg]cb'XYhJ]`g''

cfi]bZcfa Uh]cbicbi\ckihcigi Va]hUgg][ba Ybhgicbi]bYij]UiA ccXiY.i\hdg.#gh XYbh'i bgk "YXi "Ui #\ck! qi Va]hUgq][ba Ybha ccXiY

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

D`U[]Uf]ga `]g`i g]b['h\Y`k cfXg`cf`]XYUg`cZch\Yfg`UbX`dfYgYbh]b['h\Ya `Ug`mci f`ck b"'\lefi\Wb'hU_Y`a Ubm Zcfa gžZfca `XY`]VYfUhY`W\YUh]b['hc`UVW]XYbhU`mWcdm]b['Zfca `U`gci f\W' k]h\ci hUW_bck `YX[Ya Ybh'

IBGK [fcidgdu[]Uf]ga]bhch\YZc``ck]b[WUhY[cf]Yg.

7 cdm]b[.'i g]b['h\Y'gUa Y'cf'j Yfmg]a]`Uf'k cfXg'hc'h\Y'cf][]bU`h\I hcf']XYU'k]h\ci hUW_bck `YX[]b['h\Y gci fW'cf'i g]b['ei chUh]cb'a Uf_g"'H\]g'U'gc'Udd`]Yg'hc']a U[Ygž'Ufh'UbX'XYg][b'dfc YWhgž'Ug'k Y``'Ug dfYgYbhUh]cbg'k \YfY'gca YcbY'dfYgYbhg'Ubch\Yf'g']XYUg'cf'k cfXg'k]h\ci h'WfYX]h'

⇒ Uddfcdf]UhY 'dUfUd\fUg]b[.'7\Ub[]b['U'ZYk'k cfXg'UbX'd\fUgYg'k\]Y a cghmfYhJ]b]b['h\Y'cf][]bU`gffi WhifY 'UbX#cf'dfc[fYgg]cb'cZ]XYUg'cZh\Y'cf][]bU`ž'UbX']bZcfa UhJcb'k]h\ci hUW_bck `YX[Ya Ybh''H\]g'U`gcUdd`]Yg']b'dfYgYbhUhJcbg'k\YfY'gca YcbY'dUfUd\fUgYg'Ubch\Yf'g']XYUg'cf'k cfXg'k]h\ci hWfYX]h'UbX'hc