

# **MERE9452**

A UghYfg Dfc YWi6

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

GW.cc`.cZA ]bYfU'g' 79bYf[ miF Ygci fWYg'9b[ ]bYYf]b[ "#" BGK 79b[ ]bYYf]b[

# 7 ci fgY<sup>-</sup>Cj Yfj ]Yk

### GHJZZ7cbHJWhi8YHJ]`g

#### 7cbj Ybcfg

| B Ua Y           | 9a U]`                   | 5j U]`UV]`]hm                   | @cWUh]cb   | D∖cbY               |
|------------------|--------------------------|---------------------------------|--|---------------------|
| 7 Uf`]hc`HUVY`]b | WHUVY`]b4 i bgk "YXi "Ui | J ]U'HYUa gž'9a U]``cf<br>D\cbY | C`X'AU]b<br>6i]`X]b[ž'@YjY`<br>%Fcca'%)-7                        | Ž*%f&Ł'-',)<br>+-(* |
| M `>]b[          | m "Ĵb[4 i bgk "YXi "Ui   | J ]U'HYUa gž'9a U]`cf<br>D\cbY  | F cca `&% ž<br>HmfYY`9bYf[ m<br>HYV&bc`c[ ]Yg<br>6i ]`X]b[ `?!<* | Ž*&&!-',)<br>\$+,-  |

#### Hihcfg

| B Ua Y        | 9a U]`                   | 5j U]`UV]`]m                   | @cWUh]cb                                    | D∖cbY       |
|---------------|--------------------------|--------------------------------|---|-------------|
| NU_\Uf`@UbYHW | n"`UbYHW4 i bgk "YXi "Ui | J ]U'HYUa gž'9a U]`cf<br>D\cbY | HmfYY`9bYf[m<br>HYWXbc`c[m?!<br><*`&*%KG\$% | \$(*,(&,++, |

#### GWXcc``7cbHJWhi=bZcfaUhjcb

GW.cc``cZA ]bYfU`g`UbX`9bYf[mFYgci fWfg C`X`A U]b`6i ]`X]b[ž@Yj Y``%z`%) - `fP %) Ł I BGK `GM8B9MBGK `&\$) &`5I GHF 5@=5

<u>9b[]bYYf]b[ Gh XYbhGYfj ]Wg</u>

9. a YfY"hYUW]b[4 i bgk "YXi "Ui

K. <u>k k k "Yb[]bYYf]b["i bgk "YXi "Ui #a ]bYfU`g!YbYf[mfYgci fWrg</u>

# 7cifgY<sup>·</sup>8YHJ]`g

#### 7 fYX]hDc]bhg (

#### Gi a a UfmcZhXY7ci fgY

H\Y'dfc'YWidfcj ]XYg'Ub'cddcfh b]mZcf'mci 'hc'Vf]b['hc[Yh\YfYb[]bYYf]b['df]bW]d'Yg'YUfbYX'cj Yf mci f'dfYj ]ci g'mYUfg'cZgh XmUbX'Udd`mh\YgY'df]bW]d`Yg'hc']bbcj Uhj Y`mgc`j Y'dfcV`Ya g'gi W. 'Ug'h\Y XYj Y`cda YbhcZU'gdYW]Z]WXYg][ bž'dfcWYgg'UbX#cf'h\Y']bj Ygh][ Uh]cb'cZU'\mdch\Yg]g''A UghYf'dfc'YWg'UfY Wca d`YI ž'cdYb!YbXYX'dfcV`Ya g'h\UhU``ck 'fcca 'Zcf'mci f'WfYUh]j ]mž'UbX'h\Y'UWei ]g]h]cbž'UbU`mg]g'UbX ]bhYfdfYhUh]cb'cZfYgi `hg'''H\YfY'UfY'a i `h]d`Y'dcgg]V`Y'gc`i h]cbg'cf'WcbWi g]cbg'Uhh\Y'ci hgYhUbX'gi Z]W]Ybh Wca d`YI ]mhc'fYei ]fY'U'XY[ fYY'cZdfc'YWid`Ubb]b['''H\Y'dfc'YWifYei ]fYg'mci 'hc'Zcfa i `UhY'dfcV'Ya g']b gW]Ybh]Z]Wcf'Yb[]bYYf]b[''hYfa gža UbU[ Y'Ub'hYW\b]WD`'dfc'YWiUbX'Z]bX'gc`i h]cbg'VmUdd`m]b[''gW]Ybh]Z]WUbX Yb[]bYYf]b['a Yh\cXg'''Nci 'k]```U`gc'XYj Y`cd'h\Y'UV]`]mhc'k cf\_']b'U'fYgYUfW.'UbX'XYj Y`cda Ybh Ybj ]fcba Ybh''

#### 7 ci fgY 5]a g

H\Y`FYgYUfV&`H\Yg]g`]g`Ub`]bX]j ]Xi U``dfcYWi]b`k\]W&`YUW&`gh XYbhk cf\_g`i bXYf`h\Y`[ i ]XUbWY`cZU

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

H\Y`WcifgY`]g`HUi[\hUg`Ub`]bX]j]XiU``fYgYUfW\`dfc^YWfzhc`XYjY`cd`U``YjY``cZfYgYUfW\`g\_]``g`UbX Uihcbcam'

#### Df]j UhY Ghi Xm

5gʻUʻfci [\`[i]XYʻcb`mžUbʻUjYfU[YʻghiXYbhik ci`XʻVYʻYIdYWhYXʻhcʻgdYbXʻUddfcl]aUhY`m%\$ʻ\cifgʻdYf kYY\_cbʻk cf\_fY`UhYXʻhcʻh\]gʻWcifgY"`AcfY`[i]XUbWYʻ]gʻbYYXYX`]b]h]U``mZfca`h\Y`gidYfj]gcf`k\Ybʻh\Yʻhcd]W ]gʻVY]b[`XYZ]bYXʻhcʻYghUV`]g\`h\YʻcVYWfjYgʻUbX`aYh\cXc`c[mcZh\Y`h\Yg]g"

#### Gi dYfj ]g]cb

H\YfY`UfY`bc`gdYW]Z]W\cifg`Ugg][bYX`hc`h\]g`WcifgY"`AYYh]b[g`VYhkYYb`h\Y`gidYf]]gcffgEUbX`h\Y`ghiXYbh aUmhU\_Y`d`UVW`dYf]cX]WU``mcf`Vmdf]jUhY`UffUb[YaYbh'G\ci`X`gidYfj]gcfg`VY`cb`ghiXm`YUjY`cf ibUjU]`UV`Y`Zcf`U`Wcbg]XYfUV`Y`dYf]cX`cZh\Y`gYgg]cbz`U`hYfbUh]jY`UffUb[YaYbhg`bYYX`hc`VY`YgHUV`]g\YX UbX`aUXY`\_bckb`hc`Vch\`h\Y`ghiXYbhUbX`WcifgY`WccfX]bUhcf"

#### 7 cbgi `hUh]cb

H\Y`We'i fgY`We'bj Ybcf`UbX`hi hcfg`k]``VY`Uj U]`UV`Y`j]U`A]WfcgcZh'HYUa g`hc``]U]gY`k]h\`Ybfc``YX`ghi XYbhg`Ug bYYXYX"

# 5ggYgga Ybh

H\Y'UggYgga Ybhg']b'H\Yg]g'6'UfY'k cfh\'%\$i='cZh\Y'cjYfU```H\Yg]g'a Uf\_ž'Vi himci 'bYYX') \$i='hc'dUgg'cbhc H\Yg]g'7'cf'mci 'k]``bYYX'hc'HU\_Y'H\Yg]g'6'U[U]b"

### 5ggYgga YbhHUg\_g

| 5ggYgga Ybh'HJg_              | K Y][ \h | 8iY'8UHY              | GhiXYbhi@YUfb]b[<br>CihWcaYgʻ5ggYggYX |
|-------------------------------|----------|-----------------------|---------------------------------------|
| Dfc[fYgg <sup>·</sup> F Ydcfh | , \$I    | \$*#\$,#&\$&%`%%)-`DA | %ž`&ž`'Ž`(Ž`)                         |
| FYZYWJcbgJ]XYc                | &\$1     | \$*#\$,#&\$&%`%%)-`DA | &ž')                                  |

#### 5ggYgga Ybh8YHJ]`g

#### 5ggYgga Ybh% Dfc[fYggFYdcfh

#### 8YHJ]`g.

Dfc[fYggFYdcfh

 $\label{eq:main_state} Mci \ `k \ ] \ ``fYdcfhcb \ 'h \ Y \ Zc \ ``ck \ ]b[ \ ']ggi \ Yg.$ 



| ŀ\Y`fYa U]bXYf`cZ<br>H∖Yg]g | <ul> <li>H\Yg]gʻha Y`]bY`-Zcf``UghHYfa`-bchb[`W\Ub[Yg</li> <li>&gt;i gh]ZWUh]cb`cZha Y`U``cWUh]cb`Zcf`YUW\`HUg_</li> <li>5j U]`UV`Y`fYgci fWrg`]XYbh]ZYX</li> <li>F Yei ]fYX`HU]b]b[`UbX`i dq ]``]b[`]XYbhZYX</li> </ul>             |      |
|-----------------------------|--|------|
| 8cWaYbh<br>DfYgYbhJhcb      | <ul> <li>F Ydcfhcf'g`]XY glfi Wi fY UbX``Umci h</li> <li>9b[`]g\`g_]``g`-`gdY``]b[ ž[ fUa a Uf</li> <li>8 UHU dfYgYbHUH]cb f]ZUdd`]WUV`YŁ</li> <li>7 `Uf]micZk f]h]b[</li> <li>7 ]HUH]cbg Wcbg]ghYbhUbX WcffYWimZcfa UHYX</li> </ul> | %\$I |

Hi fb]h]b'gYh]b[.`H\]g'Ugg][ ba Ybh]g'gi Va ]hYX'h\fci [\`Hi fb]h]b'UbX'gh XYbhg'Xc'bchgYY'Hi fb]h]b g]a ]`Uf]hmifYdcfhg"

#### 5ggYgga Ybh& FYZYWh]cbgJ]XYc

**8YHJ]`g**.H\Y`ghi XYbhWYUf`mUfh]W``UhYg`h\Y``YUfb]b[`'UW\]Yj YX`Xi f]b[`'h\Y`dfcWYgg`UbX`\Yf`Ybh\i g]Uga 'Zcf h\Y`hcd]WUbX`fYZYWg`i dcb`h\Y`cf][]bU``\mdch\Yg]g`UbX`h\Y`bYYX`Zcf`U`hYf]b[`'cf`WUf]Zm]b[`']h'

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

I d`cUX`]bhc`h\Y`HYUa`W\UbbY``!`FYZYWjcbg`J]XYcg`Zcf`h\Y`Uddfcdf]UhY`hYfa"

Hi fb]h]b`gYh]b[.`H\]g`]g`bchU`Hi fb]h]b`Ugg][ ba Ybh

# FYgci fWfg

# DfYgWf]VYX F Ygci fWfg

Ghi XYbhgʻUfYʻYI dYWAYXʻhc.

| 9ifcdYUb'5ggcWjUhjcb'cZ;YcgWjYbhjghg'/<br>9h[]hYYfa | <u>YU[Y"cf[</u>     |
|---|---------------------|
| DYlfc`Yi a `9I d`cfUljcb`GcWjYlmcZ5i glfU`]U        | <u>dYgU"Wca "Ui</u> |
| GcWyYhmicZ9Id`cfUhjcb; Ycd\mg]Wjghg                 | <u>gY[ "cf[</u>     |
| GcWyYhmicZDYhfc`Yia '9b[]bYYfg`fGD9Ł                | gdY"cf[             |
| GcWjYhmicZDYhfcd\mg]Wjghgi/KY```@c[`5bU`mghgi       | <u>gdk`U"cf[</u>    |
| ; YcgWJYbWY <sup>··</sup> 5igHfU`]U                 | <u>[U"[cj "Ui</u>   |

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

: YYXVUW\_`Zfca `ghi XYbhg`]b`k Y`Wca YXžUbX`]g`i gYX`hc`Wcbh]bi ci g`m`]a dfcj Y`h\Y`Wci fgY ci hWca Yg`UbX`YI dYf]YbWYg`Zcf`ghi XYbhg"

#### @UVcfUhcfmK cf\_g\cd =bZcfa Uh]cb

D`YUgY`WcbHUWfimcif`gidYfj]gcf`Zcf``UVcfUhcfmYei]daYbhžUWWYgg`cf`ch\Yf`gdYWJU``fYgcifWYg`mci`a][\h bYYX`hc`Wcad`YhY`mcif`h\Yg]g"

# a ]gg]cb cZ5ggYgga YbhHUg\_g

Wkcc``\Ug'XYjY`cdYX'U'[i]XY`]bY'hc'\Y`d'mci'k\Yb'giVa]hhjb['U'WcifgY'Ugg][baYbh'

oWci fU[Y`mci `hc`fYhU]b`U`WcdmicZYj YfmiUgg][ba Ybhigi Va ]hhYX`Zcf`UggYgga YbhZcf`mci f`ck b`fYWcfX ``]b`\UfXWcdmicf`Y`YW#fcb]WZcfa "

gYgga Ybhgʻa i ghi\Uj YʻUbʻUggYgga Ybh'Wcj Yfʻg\YYhUhhUW\YX"

# fgY<sup>·</sup>Wcad`Yh]cb

jY Wead YhjebifYei ]fYgigi Va]gg]ebicZU```UggYggaYbhi]hYag"': U]`ifYiheigi Va]hU```UggYggaYbhi]hYag Ygi `hi]bih\Y`UkUfXicZUbiI bgUhjgZUWfefmi: U]`ifY`fI : E'[fUXY`Zefih\Y`7 cifgY`ib`YggigdYWjU` XYfUhjebi\Ug`VYYbigi Va]hhYX`UbX`UddfejYX"`D`YUgYibehYžU`WeadYhYbWni\ifX`Y`eZ)\$i `]g`Udd`]YXihe DU``UggYggaYbh'

# Gi Va ]gg]cb cZUb 5gg][ ba Ybh

Uf\_g`Zcf`Ub`Ugg][ ba YbhUfY`cb`mdcgg]V`Y`k \Yb`Ub`Ugg][ ba Ybh]g`fYWY]j YX`Vmh\Y`Xi Y`XUhY"`

oXYfgHUbX'h\Uh'Uh'HaYg'mci `aUmbch'VY'UV`Y'hc'gi Va]h'Ub'Ugg][baYbh'cb'h]aYž'UbX'h\Y'GV\\cc``k]`` LacXUhY'Ubm'ZU]f'UbX'fYUgcbUV`Y'YI hYbg]cb"'KY'kci`X'fYWcaaYbX'mci`fYj]Yk`h\Y'IBGK`GdYW]U` |XYfUh]cb'[i]XY`]bYg'—'gYY'gYWf]cb'VY`ck"

gi Va ]gg]cb`k ]``bchVY`UVWYdhYX`UbX`k ]``VY`Wcbg]XYfYX`Ug`bc`gi Va ]gg]cb"

# WJU``7cbg]XYfUh]cb

Wb`Udd`m'Zcf`gdYWJU``Wcbg]XYfUHjcb`H\fci [\`<u>H\Y`Bi WYi g`GH XYbh<i V</u>`k \Yb`j``bYgg`cf`cH\Yf gHUbWfg`]bH/fZYfY`k ]H\`mci f`UggYgga Ybh'dYfZcfa UbWf"`G]W\_bYggž'a ]gUXj YbH fY`cf`cH\Yf gHUbWfg`VYmcbX`mci f`WcbHfc``a Um

DfYjYbhmci Zfca Wca d`Yh]b[ UWci fgY fYei ]fYa Ybh

alimci [Zfca] "UHYbX]b[] "Ub"UggYggUV"Y"UWjj ]hm

]hhjb[`UggYggUV`Y`kcf\_`Zcf`U`WcifgY

ŶŴimci f`dYfZcfa UbW``]b`UggYggUV`Y`k cf\_žVY`]hU`Zcfa U``YbX!cZgYa YghYf WUgg`hYghžU``UVcfUhcfmhYghžU`gYa ]bUf`dfYgYbhUh]cb`cf`Ubmich∖Yf`Zcfa `cZ

YUgY \$ ‰

ga Y \_\_\_ UfX ‰

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

Mci f``YWi fYf`UbX`h\Y`I b]j Yfg]mik ]``YI dYWinci f`gi Va ]hYX`Ugg][ ba Ybhg`UfY`hfi `minci f`ck b`k cf\_"`I BGK \Ug`j YfmWYUf`[ i ]XY`]bYg`cb`k \Uhd`U[ ]Uf]ga `]g`UbX`\ck `hc`Uj c]X`]h'`D`U[ ]Uf]ga `]g`i g]b[ `h\Y`k cfXg`cf ]XYUg`cZch\Yfg`UbX`dfYgYbh]b[ `h\Ya `Ug`nci f`ck b"`D`U[ ]Uf]ga `]g`U`mdY`cZ]bhY``YWi U``h\YZh'`+i`WUb`hU\_Y a UbmZcfa gž`Zīca `XY`]VYfUhY`W\YUh]b[ `hc`UVW]XYbhU``mVcdm]b[ `Zīca `U`gci fWY`k ]h\ci hUW\_bck `YX[ Ya Ybh' H\Y`I b]j Yfg]mi\Ug`UXcdhYX`Ub`YXi WUh]j Y`UddfcUV\'hc`d`U[ ]Uf]ga `UbX`\Ug`XYj Y`cdYX`U`fUb[ Y`cZ fYgci fWYg`hc`gi ddcfhigh XYbhg''`5```h\Y`XYhU]`g`cb`d`U[ ]Uf]ga ž`]bWi X]b[ `gca Y`i gYZ ``fYgci fWYgž`WUb`VY Zci bX`Uhi<u>k k k "gh XYbh'i bgk "YXi "Ui #d`U[ ]Uf]ga</u>."

5```A]b]b[''9b[]bYYf]b['gh XYbhg'UfY'fYei]fYX'hc'Wcad`YhY'U'gh XYbhXYWUfUh]cb'Zcf'UWUXYa]W]bhY[f]hm k \]WX']g'ci h]bYX']b'h\Y'Ugg][baYbhWcjYf'g\YYhg'''6mg][b]b['h\]g'XYWUfUh]cbz'mci 'U[fYY'h\Uhmcif'k cf\_']g mcif'ckb'cf][]bU'`k cf\_"

-Zmci 'bYYX'gca Y'UXX]h]cbU``gi ddcfhk]h\ 'mci f`k f]h]b[ 'g\_]`gž'd`YUgY WcbhUWh\Y'@YUfb]b[ '7 YbhY'cf'j]Yk gca Y'cZh\Y'fYgci fW'g'cb'h\Y]f`k YVg]hY. <u>k k k "`Wi bgk "YXi "Ui</u>"'H\Y'@YUfb]b[ '7 YbhY']g'XYg][ bYX'hc`\Y`d mci ']a dfcj Y'mci f'UWUXYa ]Wk f]h]b[ 'UbX'Wca a i b]WUh]cb'g\_]``g"'Gca Y'gh XYbhg'i gY'h\Y'7 YbhY'gYfj ]WYg VYWUi gY'h\Ym'UfY'Z]bX]b[ 'h\Y]f'Ugg][ ba Ybhg'U'W\U``Yb[ Yž'ch\Yfg'VYWUi gY'h\Ymk Ubhhc']a dfcj Y'Ub'U'fYUXm gi WWYggZ ``UWUXYa ]WdYfZcfa UbWY" 5₩UXYa]W≢bZcfaUh]cb

VfcUXVUbX`V&bbYWjcb`f&) \* `\_V]h#gYWcf`ZJghYfŁ UV]`]hmihc`j ]Yk`ghfYUa ]b[`j ]XYc`f\][ \`cf``ck`XYZjb]hjcb`I BGK `HJ`cdhjcbgŁ

A cfY [bZcfa Uh]cb'UVci hgmghYa 'fYei ]fYa Ybhg']g'Uj U]'UV'Y Wh<u>k k k "ghi XYbh'i bgk "YXi "Ui #a ccX`Y!gmghYa !fYei</u> ]fYa Ybhg

# 5\WWgg]b[`7cifgY`AUhYf]U`g`H\fci[\`AccX`Y

7 ci fgY ci h]bYgžgi ddcfha UhYf]U`g`UfY`i d`cUXYX`hc`A ccX`Yžh\Y`i b]j Yfg]mighUbXUfX`@YUfb]b[ A UbU Ya YbhGmghYa `f@A GŁ"`=b`UXX]h]cbžcb!`]bY`Ugg][ ba Ybhigi Va ]gg]cbg`UfY`a UXY`i g]b[ `h\Y Ugg][ ba YbhXfcdVcl `ZJW]`]midfcj ]XYX`]b`A ccX`Y"`5```Ybfc``YX`ghi XYbhg`UfY`Ui hca Uh]WJ``m`]bWi XYX`]b A dcX`Y`Zcf`YUW\`Wci fgY"`Hc`UWWYgg`h\YgY`XcW a Ybhg`UbX`ch\Yf`Wci fgY`fYgci fVWgž'd`YUgY`j ]g]h` k k k "a ccX`Y"hY`h'i bgk "YXi "Ui

# def KY7cbhUWh1Mci

 Image: Spin Y GWL cc ``cf`mci f`Wci fgY Wcbj Ybcfg`a UmbYYX hc `WcbhUWhimci `UVci himci f`Wci fgY cf`mci f

 Ybfc`a Ybh'`Nci f`Wci fgY Wcbj Ybcfg`k ]```i gY h\Y Ya U]``Z bWjcb`k ]h\]b`A ccX`Y cf`k Y`k ]```WcbhUWhimci `cb

 mci f`4 ghi XYbh'i bgk "YXi "Ui 'Ya U]``UXXfYgg"

KYit KXYfghUbXih\Uhimci ia Umi\UjYiUbiYI]gh]b[iYaU]`iUWVci bhiUbXik ci iXidfYZYfiZcfimci fil BGK iYaU]`gihci

### 5W\_bck `YX[ Ya YbhcZ7ci bhfm

 $\label{eq:constraint} \begin{array}{l} K_{1}^{T}(UW_{bck}^{T}X_{l}^{T}) & K_{1}^{T}(UX_{l}) \\ F(UX_{l}) & F(UX_{l}) \\ F(UX_{l}) & F(UX_{$