

JYSçãÑÑ s ys-vÑÓ yÓ ÓÑŷ SéÑ# #Óúí Ó Óí

' » f E +±3 â e • 7 E/ Á Õ . E3Ô c æ" -A/£

{ &%^(SVO) wE <Kñ^(SVO) w, \ ^(SVO) w0 ~ * ^(SVO) wSñVS|

æž-D GT " 7 Ô C " K" K, >->-¶ œ@! B0 +0Ž, >-. N=y Ô c ; , , L - \ Fú%æ O' Ñ" K, >->-¶ œ@! B0
è Ž 7 WŞ GKó TM%>-¶ N=y7 Ô Ô c -A/£ m" K, >->-¶ œ@! !@

...œ@!µ & L<3ì T Ô . E3Ô c U • Ô ž ú 8 Q@ T : Bà±K MÅŷ ' - .úE/*U » /8±' » f E 3
â e • 7 E/ Á Õ . E3Ô c æ' wU » Ě g Ô c 2(4 & Ÿ • +±Q@ T ÷ ý P Ô c ú Á±ó-) T U
• Ô ž ú 8 & N, † ' 5)3±3 ½ ý ' ³ E/*U » N=y Ô c 2(4 +±f E +±3 â e • 7 E/ Á Õ . E3Ô
c æ' @î; ³ @@±Ô c • U • Ô ž ú 8 ± Ç T 1 Ô . ' T w ÷ f E ; +±3 â e • 7 E/ Á ±A
c ^ 80! & N g N , E=yüE 4 ' ³ OS5 ĚKr E Ä g Ô c L-lo±7 E/ Á Õ . E3ÿELÓ Ô c 0f*' w
£ A ' » f E ; +±æ' @@ÍÔ c , £ U " =y g ± r KÉ' Fúð/® • Ô 8 E =y, , L w&! O' @î³ ' »
f E +±3 â e • 7 E/ Á Õ . E3æ' @@±Ô c • +±Q@ T 1 Ô . T6* 4 É=• ; ' » f E +±3 â e
• 7 E/ Á Õ . E3Ô c ¼ 6Q@ T g Ô c 1ëÓP ±! %æ

œ@| œ@Ű E/ Á Õ . E3Ô c f E +±3 â e • 7 E/ Á >ÿELÓ Ô c , Q@ T
Z + 3 1" \$ ÅÆx Žœœœ' ([4 -. Åœœœœ' 0 4C\$ ÅR!!!K@ %@! 0B0! BK B @K

œœ , ý P 7WŞ • ¶ • T 1 L • T - , ! \ & %æ
MÅ%UN =yDð8 Z " 1.ú : -> Ç 2M±...UF* G &
N g +±N =yT6* Ô*L ž ú %, - " E Ä g p 1) f
÷ DýDÀg { /§/§ ÂF* G f N g Fúð z 4 } " 59Fú
ð z 4 } ; N g ± Ô . T6* 1 / Ç T 6, mó 4 ±±
2(" Fúð ±± C GKz{ Ô c T6* *G7 -a | N g 7 C@
±± Ç T %' C " " =y g ± r KÉRFú . 5î, mN g ¶
• N=y ÷ N=y ..±±*L a ¶ • % ' " E@ðý P N
=y Ô c 2(4 +±Q@ T " - £ UN =y Z h Ô C52=Ø
x : mEt] Ÿ • " & N g ¶ • N=y ¼ 6# E ±± < v %
B 0 j " " 52 i ç 0v ^(S)NÑN 3 L<3ì T Ô . E3
Ô c æ' %è•ç=ç Uç fçU ç=ç=ç=ç " ¶ÔçÁ*U]
E Ä g Ô c , @@ÍZ " ' 7Ÿ] , (Ÿ ' ¶Ôçæ' EL
T a ÷ ? 5S6* Ě g ±±! %æ*^ » ¶Ôç Ô c æ"
±±! %æ 5 ³ (Ÿ E g & T6* ±±@o " 59A æ"
- 3ü ý ' " ^ Ä] ³ * ² C " 52±±- " " %
*^ » 11" 2M±c 3Ó1 K } c " ĚKr /8 Z Kë
8ä 1ë-) ±A Ô • > ") 7! ¶Ôç Ô c • " 1ë-) µ
K' N g ZL<3ì TF 3 " E 59Kz{ ³ Ô c T6* %µ &

¶ÔçáL_ ' Q@ T : Bà±K MÅ' D G " 52 & A æ'
E =y f E " U *† £ E.í ' T +±9 # " Kz { ¶Ôç
æ' & 1ë-) N , ±±ĚBf" Dè] ý P ¶Ôç Ô c • +±Q@
ÿ T ±± , ±±% f > * ² C " 52 p = ±±' 0 ' , 8 " &
¶Ôç Ô c ±± f E æ < h > @Kó Z U Ě Fú ¶Ôç
%æç Uç] çW ¶Ôç' ¶Ôç ^(K) 1 7 E/ Á ¶Ôç%µ Uçwè
¶Ôç' ò ¶Ôç ^(K) Q æL • % ¶Ôç Ô c æ' Fô*U " ÿ 3Ô
• , - ±±æ < & N , E =y 0- C " Ä] Ô c DÀ' Ě Fú
; ' ä . FÜx K! ±± 2(" E 59Fô*U ¶Ôç Ô c eú \$ Alo
E3| ±±æ' Ô) ' ¶Ôç Ô c , %*^ » ¶Ôç Ô c ,
ZFô*U > ý Í ELÓ \$ ' , Ì Y ¶Ôç Z ; L<3ì T
N , % ±± œ" 59 ¶Ôç Ô c , UKz { & N , ±±
ĚBf +±9 # ý P ³ 2(4 & • Ô ±±Q@ T ^(B) B '
> ý Í ELÓ \$ \ ¶Ôç ±±1èP " s \ ĚKr Z Í 6, % Á
±±ML • è , ! Ò " x FÜ > ý Í ELÓ \$ " £ AEGe Fô*U
& > ý ELÓ \$ 3 \$ " ±±æ < ' 8ä > ý Í ELÓ %*^
» E - Dð8 µ Kë @îĚ # T " £ A Ä] ±± > ý Í ELÓ
\$ Z ±±A E G, ! Ò Kz {] ¶Ôç ±±Q@ T ^(O) °
' E & ¶Ôçæ' ±±ĚKr Á*UEM= ³ - WR (±±

> E %

7 E/Á Ô c F \ U Ô c • Z Í ' 7 E/Á 4 ± " f > Ö . A] @Í N , : -> Ç T ÷ • Ö & 2(4 Ô * L + ± ž ú " U Ô c • Z µ = ' - " Dë] ý P Ô c • Q Ö y T + ± , ± % , z & 7 E/Á Ô c) 3 @ç Á * U + ± A / £ D ° g = & ì " ¥ , + ± 7 E/Á Ô Ä " F * 2 . < 3ü4-4 7 E/Á ° & Æ 7 E/Á Æ Ö v % ' 3 ¶ Ö ç Ô c ; 7 E/Á Ô c 4 5 " ý ' 7 E/Á Ö . E 3 Ô c æ " ' È g ¶ Ö ç Ô c • + ± Q Ö y T % , % ! » ç ¶ Ö ç ' ö ¶ Ö ç : L - > ® B ' MË C + ± > ý Í E L Ó \$ " £ A ö ¶ Ö ç Ô c æ " + t ¶ Ö ç Ô c E 7 æ ± Ö . ' T 1 ? 5 S 6 * È + ± 9 # " © M « 7 E/Á Ô c + ± Q Ö y T " - Ä ' » ' æ " @ @ Í ± Ô c • 6 * L x : N = y D ð 8 Z • Ö & N g + ± ž ú % ' ([x Ö µ & P B 2 E I N g ý ' - . ú 7 E/Á Ö . E 3 Ô c È g Ô c 2(4 + ± Q Ö y T " x : 3 P E L Ž # 8 + ± g 5 S 5 T 1 g L < 3ì T & N g + ± ž ú " - 3 ð È (Ý 3 m L H + ± C W T 6 * % ' ([" Ö µ & 7] D a g , m 7] K M Ä ' ý ' - . ú ' » f E + ± < 3ü4-4 7 E/Á Ö . E 3 Ô c æ " " £ ' » ' æ " @ @ Í 7] D a g 3 â > Ô c , * U " µ K ' 7] k " n & 7] D a g ž ú % ^ » A æ " B ' 7 E/Á " • (' í ' . < 3ü4-4 + ± c ^ E L Ó " E 5 9 @ í Ô c • + ± Q Ö y T " ý P 3 , m 7] 1 è Ó % ' ([Ö 9 d 3 . < 3ü4-4 1 Ö . E 3 æ " 4 5 " f > - E Ô c) 3 @ @ @ Í < 3ü4-4 p i + ± 7 E/Á , % U N g b * L 7 b L • r K É # " . < 3ü4-4 p i E = y A 0 j " F ú ± ' 7 b L • r K É m) 7 ! + ± A " £ ^ Ô c • E = y = ' - " ú , , L 4 É ' , 8 A æ " D ë] M ± L + ± Ô c u É " @ 7 b g r K É 8 N g + ± ú 3 â î B U %

7 E/Á Ô c g 3ì 20" g 3 ? à Ö . E 3 æ " & ï • • Ó | L + ± K M Ä ' Y ' ý ' - . ú ' » 3 â e • + ± 7 E/Á Ö . E 3 Ô c 0 f * " £ & 3 â e • 7 E/Á Ô Ä " Æ E = y f E " U ü < ê D ý = y B L ò + ± 9 # ý P A Ô Ä " & • Ö ž ú] @ Í ± 1 è Ó % ' C " ' » f E + ± 3 â e • 7 E/Á Ö . E 3 Ô c @ @ Í u E E Ä g Ô c , % , , L 4 É = • ; " Y ' m @ @ Í ± Ô c • 6 * L È g Ô c 2(4 + ± Q Ö y T " µ & F ú ð / ® ÿ • 1 " = y g ± r K É " A Ô c • 6 * L 6 u x : 7 • Ö + ± ž ú " & » N g + ± ¶ • N = y µ 6 - Ç + ± / 8 Á * U \$ i %

Ö ç 7 E/Á Ö . E 3 Ô c æ "

7 E/Á Ö . E 3 Ô c • * ^ Ö . E 3 Ô c • & ï 50 N , 1 7 E/Á , 6 F 3 3 ñ = % £ Z ï 50 N , ý È L H

+ ± 2(4 Ö . T 6 * 7 E/Á , 1 Ô c , F f > 2(4 ; ï 50 N , x K ! + ± ú Á A & • Ö E = y] @ Í ' = ' - " ð - = Ö Ö & A Ž È] \$ < + ± Ö . T 6 * % Y 7 - h > ® & ÿ • ž ú 8 + ± N , E = y 3 1 2 " £ A @ @ Í % Á + ± Ô c , & ï 50 N , 1 7 E/Á , % Ö Ö ç ÿ • ž ú 8 + ± N , 3 1 2

E G e ò â " • Ö 8 + ± 2(4 Û 3 æ / 8 = • E g â { x % o = f % o o + G % o o l % o o u % o o + δ % o ' t o % o } { y % o = C x % o < Z â x % o â t n x ß \ 2(4 ' ä . f % o o â t n x ß = • g ; Ô c + ± 2(4 L < 3ì T v # p > F ü * • G % o o â t n x m % o j m o = • g ; Ô c , % + ± 2(4 Ô c u 6 * - K b µ % o o â t m x ß \ 2(4 + ± Ô c D Ä ' € â t m x n g 2(4 D Ä ' - K b 5 9 y % o o â t m x ß = • g 2(4 + ± D Ä ' % ! X + ± " λ % o o â t m x m = • g D Ä ' È + ÷ & > ÿ - K b 6 % o ' t o â t n x ß = • g 2(4] + ± • Ö " 2 N , : -> Ç T & C F • Ö 0 v % 2(4 \$ B à 8 W t @ ä

t @ è Ö e 2(4 Ô c u 6 * - K b + ± E 3 % W E 3 o ... U % G % o o ß G % o o = I C G % o o ß G % o o = I % t @ è # œ • Ö δ % o ' t o • m 6 * y % ... U e • D > ! 1 X > ! " - Ä • Ö U (< # h t > ! " A ' ä . F ü 6 * y Ä x Ä j X + ± 80 ! 2 \$ B à Ä δ % o ' t o Ä j D % t @ è ü œ • Ö δ % o ' t o |) • ... U A 6 * y % ... U e • d δ γ > ! 1 d δ γ > ! " F • Ö |) • \$ B à

$\left\| \frac{\mathbb{N} \% o ' t o}{N x} \right\|_ > j d_{\delta x} < > " \left\| \frac{\mathbb{N} \% o ' t o}{N} \right\|_ > j d_{\delta i} < > \% o$
 œ æ t @ è ! œ D Ä ' È + ÷ K b λ % o \ 0 S \$ - + ± < t / & > ÿ - K b " £ & > ý 3ì p 2 M λ ii % o = ß " 0 - n o \$ B à ! j λ ii j ß %) 3 ò â 8 g , z K b + ^ É F 3 Ô c L • T 6 * K z 3 Ö " F & Á p 2 M λ ii â % b " ß o + ^ É 1 • ^ u F & Á p 2 M λ ii g L # %

* ^ » Ô c • L - > ® x : ÿ • ž ú " ' 1 " ! ï 50 ' ([ß Ò 3 2(4 % ß o £ • = 8 • < { x % o = f % o o + G % o o l % o o u % o o + σ % o ' t o o % o } { y % o = C x % o < Z " σ % o ' t o 1 δ % o ' t o \$ B à δ % o ' t o = G % o o r % o " t o %

Ö ç ± 7 E/Á Ö . E 3 Ô c • @ @ Í F ô U ú N µ o E 3 + ± J @ @ Í Ö . E 3 Ô c , " Ö . E 3 Ô c , - 8 u % o = λ i ß G % o o ß % b γ % o o - f % o o o o - λ i ß σ % o ' t o % o

æœ™ < Z "σ %o"i o g • Ö ž ú +±] @Î" ^ 7 E/ Á
 , : Ú ! Ý " 8 - 7 3 A 3ó4 ' @ @Dð8 %λ , g
 - 4/ 2(4 +±DÀ' È +÷ Kb%σ_d \ W Ô c DÀ' " =•
 .g 2(4 L H +± Ö . " E FÛ ^ 3i T Ô c • %o @ @Î %

$$v_d \%o = K_{\omega} \%o_{ij}, \%o - x \%o_{oo} \%o$$

< Z â K_ω g & ÿ È +÷ Kb" \$ Bà K_ω "i > ! " i = ß" 0- n +
 x_{ij} , g 2(4 +±DÀ' 4 %

Öž† ï 50 N , @ @Î

ï 50 N , +± ì 6* \ g 2(4 ú Á ý È +± ï 50 % £
 ì 6* à Ç³ ï 50 N , π 6 2(4 L H +± Ö . % ' ï
 50 N , +± ú Á \ = ð Ô & A Ž 3 +± ú Á % 50 ; ~] 7 E/
 Á Ö . E3Ô c , %x o < " 2(4 ï 50 N , @ @Î g

$$\dot{x}, \%o = -Ke \%o + f \%o +$$

$$o e G \%o o \%o , \%o \alpha \%o + \sigma \%o "i oo \%o$$

< Z â x %o â t^{n x ß} g ï 50 N , +± ä . FÛ e %o â
 t^{n x ß} = • g ï 50 N , ; 2(4 x K ! +± A "

$$e \%o = \dot{x} \%o - x \%o \%o$$

Öž† ' » f E +± 3 â e • +± 7 E/ Á ,

7 E/ Á , f > ï 50 N , ; 2(4 ú Á x K ! +± A
 ' ! Ý ï • σ %o "i o " 3 £ ú N μ 7 E/ Á Ö . E3Ô c
 • & 2(4 E = y A 0 i % @ K (Ü 2(4 \$ 6 * y +± 9
 # " - Ä 2(4 DÀ' ú Á C CV ÷ ï 50 N , +± DÀ' %

3 â e • 7 E/ Á Ö " \ - . ú ¥ , +± 7 E/ Á , +±
 @ @Î æ" % A Ö " 6 8 W : , +± E ï á U
 A Ö " 4 ± 0- , @ ð Ä F ü < " : G 4 2(4 S ' M Ê C B L
 ò + & 6 * L @ 2(4 \$ +± w • m - 7 ! * y T +ù o U
 @ 2(4 / . T +± 9 # @ M e 3 2(4 +± Ü . T 6 * %

3 â e • 7 E/ Á 6, m ; ê , % 9 +± F ð d M % 4 %
 € 2(4 F ð d K ! K Á T , B . < " 2(4 ú Á +± f . A B .
 < " ' E G e E ð ð ü < F ð d K ! K Á ' 4 V < / . A
 +± y " s E d G T T È Í ê +± B L ò % 59 " Y
 ' & ï 50 ' ([ß ß Ö m * U] +± 3 â e • 7 E/ Á E = y
 f E " f E ; +± 7 E/ Á , U , % 9 Ž # 8 ý P m] @ Î
 σ %o "i o +± 1 è Ö " 4 V < 2(4 / . A e %o % f E D ð 8
 A > î O Y Ö ž 7 / Ç T 3 ½ " F ð * U f E ; +± 3 â e •
 7 E/ Á Ö " @ @Î +± 7 E/ Á , g

σ %o "i T_s o = - G %o o + Φ %o o^{-ß} η %o T_s o %o o
 < Z " Φ %o o¹ η %o T_s o π €⁻ 8

$$o e \Phi \%o_o = -K^{-\beta} \%o^{-KT_s} - I_n o \%o$$

o e η %o T_s o = %o^{-KT_s} + K_σ I_n o %o %o T_s o - x %o T_s o o %o
 U 7 E/ Á , Z " T_s g 2(4 F ð d # K ! K Á T_n g n K c ,
 z K b K_σ = • g È g } +± & > ÿ - K b " £ %o U \ ý P

2(4 / . 1 è Ö % ! X +± " & > ý 3 i p 2 M \$ Bà
 K_σ "i â %b " ß o " %o = ß" 0- n o

#† Ö c 2(4 T 6* 3 ½

U & 7 E/ Á Ö . E3Ô c T 6* 3 ½ x z " Ç v U
 3 ½ D ð 8 Z * U] +± - È ï • %

Ç v ζ %o_o ÷ κ %o_o o μ g * ^ Ö c DÀ' 1 Ý • B
 B π ± ä . DÀ' +± 7 * y " £ Z κ %o_o ; μ +± Ç v - 8
 κ %o_o o = Üⁿ -K %o_o - τ ° G %o o Ä_o) T %o ß o

$$\Delta = \frac{\alpha_{ij} \lambda_{ij} - \lambda_i \dot{\lambda}_j}{e} + \frac{D}{AG \%o o \dot{\lambda}_o} \ddot{m}$$

$$\alpha_{\beta} \%o " \alpha_o \%o " \alpha \%o + \pm \zeta v \pi \in^{-} 8$$

$$\alpha_{\beta} \%o = \dot{\lambda}^{-K_t} \dot{\lambda}_o$$

$$\alpha_o \%o = \ddot{\lambda}^{-K \%o - \tau} \Phi^{-\beta} \%o_o^{-KT_s} \dot{\lambda}_o) T$$

$$\alpha \%o = \ddot{\lambda}^{-K \%o - \tau} \Phi \%o_o \dot{\lambda}_o) T \%o$$

æœ U F ð d • L T_s² α_β %o " α_o %o " α %o + ± - T i
 = • g g

$$\alpha_{\beta} \%o_o =] U \alpha_{\beta} \%o_o$$

$$\alpha_{\beta} \%o_o =] U \alpha_o \%o_o$$

$$\alpha_{\beta} \%o_o =] U \alpha_{\beta} \%o_o \%o \times o$$

#ž† / Ç T 3 ½

%o o < ; %o o < , %ü 6* L Ä] A Ö .

$$e \%o = -Ke \%o + G \%o o \dot{\lambda} \%o "i o \%o$$

< Z " ð %o "i o = • g • Ö] @ Ä " π € < - 8

$$\dot{\lambda} \%o "i o = \dot{\sigma} \%o "i o - \%o - \lambda_i \alpha \%o + \sigma \%o "i oo \%o$$

æœ U i T_s + t # h 8 " 2(4 +± A Ö . æ / 8 +± ? g
 e %o T_s + t o = -K_t e %o T_s o +

$$o e \ddot{\lambda}^{K \%o - \xi} G \%o o \dot{\lambda} \%o T_s o \xi -$$

$$o e \ddot{\lambda}^{K \%o - \xi} G \%o o \%o - \lambda_i \alpha \%o T_s + \xi o +$$

$$o e \sigma \%o T_s + \xi o o \xi \%o$$

æœ Ç v ' ä . FÛ U i T_s # h ' ä . A B B π ± ?

$$\zeta_{\beta} \%o T_s + t o \div -K_t e \%o T_s o +$$

$$o e \ddot{\lambda}^{K \%o - \xi} G \%o o \dot{\lambda} \%o T_s o \xi \%o$$

æœ9 d "Ç v Ÿ • Mi! U iT_s # h BB±±?

$$\zeta_0 \%T_s + t o \div - \ddot{U}^{K \% \sigma - \xi \%} G \% \alpha o \frac{1}{4}$$

%% - λ₁ α %T_s + ξ o + σ %T_s + ξ ooξ %B o

æœU # K!K!KÁ jT_s " %ot BσT_s Ò² "A %ot BσT_s <

τ "F %ot BσT_s # h 82(4 +±M±xA g

e %ot BσT_s o = ζ_B %ot BσT_s o + ζ₀ %ot BσT_s o

%! o

< Z

$$\zeta_B \%ot B\sigma T_s o = -^{KT_s} e \%T_s o +$$

$$\text{æ } \ddot{U}^{K \% \sigma - \xi \%} G \% \alpha o \sigma \%T_s o \xi \quad \% \text{B} o$$

$$\zeta_0 \%ot B\sigma T_s o = - \ddot{U}^{K \% \sigma - \xi \%} G \% \alpha o \frac{1}{4}$$

æ% - λ₁ α %T_s + ξ o + σ %T_s + ξ ooξ %B o

æœU f E ; +±3 â e • 7 E/ Á_s %o o 2%B! o < %o

*U 8 ζ_B %ot BσT_s o g

$$\zeta_B \%ot B\sigma T_s o = - K_\sigma e \%ot B\sigma T_s o \quad \% \text{B} o$$

æœ3 %o o < '] M±xA æ/8 %! o < Z " E

- ' , g

$$e \%ot B\sigma T_s o = \%_o + K_\sigma \sigma^{-\beta} \zeta_0 \%ot B\sigma T_s o \% \times o$$

æœ^ » Ÿ • +±\$ Bàt @ë0" £ A f > %Bso < 1

%B o < & κ %₀ o 1 μ ± ± Ç v " Ä

$$\text{Ä} e \%ot B\sigma T_s o \text{Ä}_0 = \text{Ä} \%_o + K_\sigma \sigma^{-\beta} \zeta_0 \%ot B\sigma T_s o \text{Ä}_0$$

$$\text{æ} j \text{Ä} \%_o + K_\sigma \sigma^{-\beta} \text{Ä}_{\sigma} \% \alpha \text{Ä} = \text{Ä} \%_o + K_\sigma \sigma^{-\beta} \text{Ä}_{\zeta} \% \alpha \text{Ä}_o$$

%B" o

æœ%B" o < Ä] +±7*y & m6 %ot BσT_s j τ F* =

/ø " ' & » iT_s j τ "%B o < 9 d = /ø %

$$\text{Ä} e \%T_s o \text{Ä}_0 j \text{Ä} \%_o + K_\sigma \sigma^{-\beta} \text{Ä}_{\zeta} \% \alpha o " \text{Fi} T_s j \tau$$

%B o

æœU m6 iT_s + t j τ "t â %B" T_s Ò ± 80! ² "f >

< %B o & α_B %o "α₀ %o "α %o 1 μ ± ± Ç v "A +±

1 80 • - 8

$$\text{Ä} e \%T_s + t o \text{Ä}_0 j \%_B \% o +$$

$$\text{æ} x_0 \% o o \text{Ä} e \%T_s o \text{Ä}_0 + \alpha \% \alpha \quad \% \text{B} \text{B} o$$

æœ3 %B o < S ' %B o < " • g

$$\text{Ä} e \%T_s + t o \text{Ä}_0 j \text{Ä} \%_o + K_\sigma \sigma^{-\beta} \text{Ä}_0 \% \alpha \text{Ä} \% \alpha o +$$

$$\text{æ} \tilde{\alpha} \% \alpha o \alpha \zeta \% \alpha o + \alpha \% \alpha o \mu \quad \% \text{B} o$$

æœ3 Ò Ç v g γ₁ %₀ o " > î %B o < %

$$\gamma_1 \% \alpha o \div \text{Ä} \%_o + K_\sigma \sigma^{-\beta} \text{Ä}_0 \% \alpha \text{Ä} \% \alpha o +$$

$$\text{æ} \tilde{\alpha} \% \alpha o \alpha \zeta \% \alpha o + \alpha \tilde{\alpha} \% \alpha o \mu \quad \% \text{B} o$$

æœf > %B o < 1 %B x o < +± Ç v : Kë Ö "

$$\ddot{\alpha} \tilde{\alpha} \% \alpha o = \ddot{\alpha} \alpha_B \% \alpha o = !$$

$$\ddot{\alpha} \tilde{\alpha} \% \alpha o = \ddot{\alpha} \alpha_0 \% \alpha o = !$$

$$\ddot{\alpha} \tilde{\alpha} \% \alpha o = \ddot{\alpha} \alpha \% \alpha o = !$$

%o! o

æœem "€ # K!K!KÁT_s μ < # "A +±@K} g

$$\ddot{\alpha} \gamma_1 \% \alpha o = !$$

%oB o

æœ ' & » (< t â ! "τ Ò F* 6

$$\text{Ä} e \% \alpha \text{Ä}_0 j \gamma_1 \% \alpha o j \tilde{\gamma} \tilde{\alpha} \quad \% \text{B} o o$$

< Z "γ̃ g (< < +± • e • %û 7 E Ò) Dð8 6* ;

k, 8 ' 8 " ! %æ

$$\text{B} o \cdot \tilde{\text{O}} \tilde{\text{z}} \tilde{\text{u}} 8 " ' \gg f E +\pm 3 \hat{a} e \cdot 7 E / \hat{A}_s$$

%B o ~ %B! o < o U # K!K!KÁT_s 6* L @ 2(4 +±

Ç T % ' U j WÔ c Dð8 "2(4 +± • m/ Ç 1 , Û

. T6* F* Ä] ³ @î %

$$\text{O} o \text{E} \text{D} \text{ö} \text{y} P M \frac{3}{4} ' \ddot{u} < \# K!K!KÁT_s 6^* L 6 u$$

Kz{ A +±80! "E 59ý P 2(4 ú Á/ . 1ë Ó "s ;

' 9 # G È Í ê ±BLò %

$$o^{\wedge} \gg \text{Ä} \%_o + K_\sigma \sigma^{-\beta} \text{Ä}_0 < \text{B} " ' \ddot{E} g \}$$

K_σ +±Í ' 4V < ³ A +±c ^ T80! %f E ; +±3

â e • 7 E/ Á6* L U : ù < # K!K!KÁT_s +±Ž # 8

ý P] @î ë Ó "E 59Dè] ù < 2(4 +±A +±, +± "E -

z ³ È Í M¾ & ê EM=D F Û B L ò %

#ž± Ò . " T 3 ½

$$\text{€} \text{F} \text{ô} \text{d} K!KÁT_s \mu < \# " * * 2(4 ' \tilde{a} . A$$

%' # g ³ 3 ½ 2(4 +± Ò . " T " B ' L < 7 E/ Á

• < +±K (Û Ò . 2(4 " - %o o < m.g

$$\ddot{x}_{e_1} \% \alpha o = f \% \alpha o_{e_1} o +$$

$$\ddot{i} \text{œ} G \% \alpha o_{e_1} o \% \alpha o_{e_1} o \alpha u_{e_1} \% \alpha o + \sigma \% \alpha o_{e_1} " t \text{oo}$$

$$\ddot{i} u_{e_1} \% \alpha o = \lambda^{-\beta} \% G \% \alpha o_{e_1} o^+ \% \alpha o_{e_1} \% \alpha o - \quad \% \text{B} o o$$

$$\ddot{i} \text{œ} f \% \alpha o_{e_1} \text{oo} - \sigma \% \alpha o_{e_1} " t \text{oo}$$

$$\ddot{y}_{e_1} \% \alpha o = C x_{e_1} \% \alpha o$$

æœ ' # "4 5 %B o < "K (Û 2(4 ú Á g

$$\begin{cases} \ddot{x}_{e_1} \% \alpha o = - K_\omega \% \alpha o_{e_1} \% \alpha o - x_{ij} \% \alpha o \quad \% \text{B} o \times o \\ \ddot{y}_{e_1} \% \alpha o = C x_{e_1} \% \alpha o \end{cases}$$

$$\text{æœ} \text{€} A \ddot{\alpha} x_{e_1} \% \alpha o = \frac{K_\omega}{s + K_\omega} x_{ij} \% \alpha o " \tau \hat{a} \% \text{B} " T_s \text{Ö} \%$$

ï 50 N_s g - Kc T(Û7 % ' , 8 ' €E6

5E/Fôd K!KÁT_s " U f E ; 3 â e • 7 E/ Á Ò . E3

Ô c_s %s U 82(4 6* LDè] mL H ± ± Ò . T6* %

ú† 7 E/ Á Õ . E3>ÿELÓ Ô c , @ @ Î

ú† N , ü E

ý , u E E Ä g g , "A E g ú 3â g ± 2
œ) δ_{a,r} "δ_{a,r}" • Õ k δ_{e,r} "δ_{e,r}" z 4E>CE

5) δ_r "δ_r" æ > 7bδ_r 1 T Õ È p Õ g % E Ä g BU
Füg 0 " . xx ' k"5) L • L • / S g 0 @ @] 0" t ! A Õ
S J - c 3/4 . x"] 5) , b g . 3xx] %

z 4E>œ) ± ± Ô c 4 * ^ D ù ÿ α & † , p_s 1 Õ ,

Q f) Ô c * • 7 Õ * L = " Ô c , - 8

$$\delta_{r_1} = \delta_{r_2} = ! \cdot \frac{Q}{p_s} + \beta \frac{Q + \frac{R}{\sigma}}{s + \frac{R}{\sigma}}$$

%o" o

œœE G e ò â 8 " E Ä g >ÿELÓ D ý Õ æ 8 A E g

$$\dot{\omega} = J^{-\beta} \dot{M} - \omega \times J \omega$$

< Z â ω = p q r Ò = • g >ÿELÓ # = • D T Õ F ù
K b % 3 E g m È - M = L " M " N Ò ó 3 g ! A Õ È
Ô * L ± ± A Õ È - M₁ 1 ú 3â L • | D T Õ * L ± ± ú 3â È
- " ú 3â È - ò ó 3 g ú 3â) • - K b C_{M_c} ; ú
3â L • | D T Õ , % .. ± ± • < " α € = • D è g

$$\frac{\partial C_l^M}{\partial \beta} p " r " Ma \dot{\omega}$$

$$\dot{M}_1 = QS \frac{\partial C_{l_m}^M}{\partial \beta} q " Ma \dot{\omega}$$

$$\frac{\partial C_n^M}{\partial \beta} p " r " Ma \dot{\omega}$$

$$C_{M_c} = QS \begin{matrix} \frac{\partial C_{l_{\delta_a r}}}{\partial \beta} & \frac{\partial C_{l_{\delta_a \gamma}}}{\partial \beta} & ! & ! & \frac{\partial C_{l_{\delta_r}}}{\partial \beta} \\ \frac{\partial C_{m_{\delta_e r}}}{\partial \beta} & \frac{\partial C_{m_{\delta_e \gamma}}}{\partial \beta} & ! & ! & \frac{\partial C_{m_{\delta_r}}}{\partial \beta} \\ \frac{\partial C_{n_{\delta_a r}}}{\partial \beta} & \frac{\partial C_{n_{\delta_a \gamma}}}{\partial \beta} & ! & ! & \frac{\partial C_{n_{\delta_r}}}{\partial \beta} \end{matrix} \dot{\omega}$$

$$u = [\delta_{a,r} \quad \delta_{e,r} \quad \delta_{c,r} \quad \delta_{e,r} \quad \delta_r]$$

< Z â Ma g O B • €_l C_m C_n = • g K' è ú 3â) • x
C ± ± A Õ) • x 1 " α € 2 L † Ç) • & k h i) •
1 L Ç J - I A Õ ä . 0 v € C_{l_{\delta_a r}} C_{l_{\delta_a \gamma}} C_{l_{\delta_r}} C_{m_{\delta_e r}} C_{m_{\delta_e \gamma}} C_{m_{\delta_r}} C_{n_{\delta_a r}}
C_{n_{\delta_a \gamma}} C_{n_{\delta_r}} g 1 Ô c L ± ± ú 3â) • %

E Ä g Ô # >ÿ D ý Õ æ 8 ü E g

$$\beta) p = \alpha - r \dot{\omega} \alpha + \frac{g}{V_a} \dot{\omega} \theta = \varphi$$

< Z â g F ú È Í ELÓ # = • g , L / § EL † 1 θ 3 X = •
g § D T Õ 1 >ÿ %

ú † >ÿELÓ Ô c 0 f *) ÷ Ô c • @ @ Î

& » 3â D_i 1 Ô D_i " N = y .. ± ± s 4 3 X , ! Ô &

ÁN g ± 1 \$ D T Õ ý Õ % N = y D ð 8 Z ^ » : 9 H

Ô # >ÿ Ô * L " ' U æ > D_i 7 6 C T & Á Ô # >ÿ 4

59: ° \ | 7WÿELÓ " i @ N g + ± Ô # >ÿ g ! %
>ÿELÓ Ô c , ± ± T 6 * , ! Ô ž ú] N g ± ± ú 3â Î

BU % Î BUE . í ± ± >ÿELÓ Ô c , > @ @ Î U 1 . ú : -) Ç
• Õ 8 N g ± ± >ÿELÓ F * 6 * C CW O < O £ .. ± ± 4 "

' F Ô * U ' » f E ; ± ± 3 â e • 7 E / Á Õ . E 3 Ô c æ
" ' ý P >ÿELÓ Ô c , ± ± Q & ÿ T % 7 E / Á Õ . E 3 Ô
c , @ @ Î g

$$u \% \omega = \lambda_1^{-\beta} \dot{\omega} - \beta C_{M_c} \omega + \omega_{01} \% \omega -$$

$$\omega = J^{-\beta} \dot{M}_1 - \omega \times J \omega - \lambda_1^{-\beta} \sigma \% \omega + \omega_{01} \% \omega$$

œœî 50 N , @ @ Î g

$$\dot{\omega} \% \omega = -K_e \% \omega + J^{-\beta} \dot{M}_1 - \omega \times J \omega +$$

$$\omega \% \beta C_{M_c} \omega + \omega_{01} \% \omega + \sigma \% \omega + \omega_{01} \% \omega$$

œœ' » f E ; ± ± 3 â e • 7 E / Á , g

$$\sigma \% \omega = -\beta C_{M_c} \omega + \Phi \% \omega - \eta \% \omega , o \% \omega$$

< Z " Φ % ω o 1 η % ω , o - % ω o ~ % ω o < m g %

50; ~] Ô # >ÿ ú Á ELÓ E • » | 7WÿELÓ ú

Á " ' f) t / q Õ) 3 @ Ç U Ô # >ÿ C # @ Î g

| 7WÿELÓ 3ü C CW m 4 4 % ' 3 Ô # >ÿ Ô

c • ± ± D À % o g | 7WÿELÓ ± ± 4 %

* ^ » Ô # >ÿ ; | 7WÿEL (x K ! ± ± , 2 (, % &

2 • " 59 F Ô * U / 3 < Õ . E 3 æ " @ @ Î Ô # >ÿ Ô c

, " α € @ @ Î 8

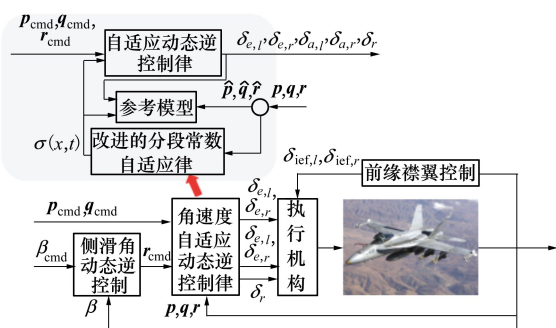
$$r_{ij} = \frac{-\beta \alpha}{\dot{\omega} \alpha \epsilon} \dot{\omega} - p = \alpha + \frac{g}{V_a} \dot{\omega} \theta = \varphi \frac{\ddot{\omega}}{\dot{\omega}}$$

< Z " ν_β = • g Ô # >ÿ ± ± † Ô c F ù " α € - 8

$$\nu_{\beta} = \frac{\alpha}{\epsilon} K_{\beta} + \frac{\beta}{s} K_{\beta i} \frac{\ddot{\omega}}{\dot{\omega}} \% \omega_{ij} , -\beta o + \beta_{ij} , \% \omega \times o$$

< Z " K_β = 0 " K_{βi} = ! . 0 " %

4) 7 " E Ä g >ÿELÓ Ô c 0 f *) - + β m g %



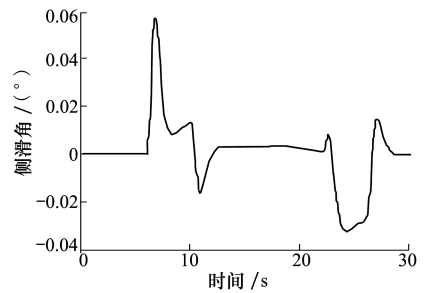
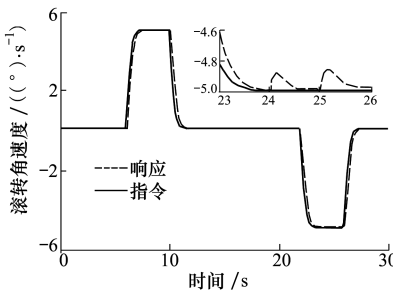
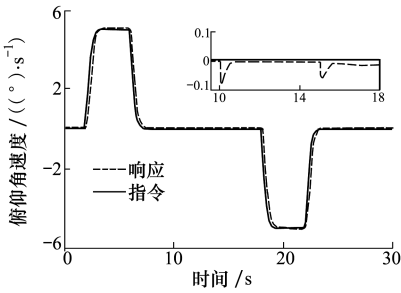
+ βœ' » 7 E / Á Õ . E 3 Ô c ± ± >ÿELÓ j € Ô c 4 ±

1. 引言

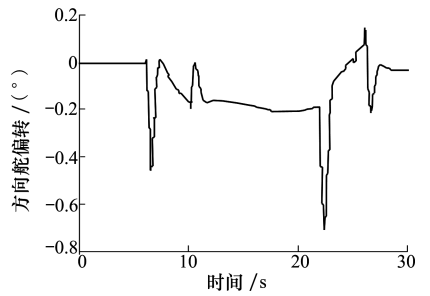
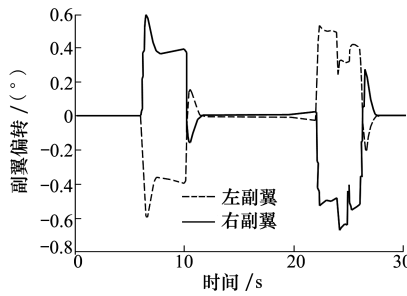
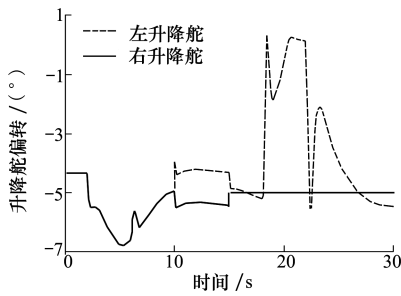
Y7F0*U J UM&δ ÷ ü ÷ ' & mf E ; ±3 â e
 • 7 E/ Á Ö . E3Ö c > ÿ ELÓ Ö c • ± Q ÷ T 1 Ö .
 T6*E =yO1@î 3 ½ %

m 6 , ,LF* U !!!] P Ó "ß" !] ð ELÓ ±
 7WÛ # 8 1 = %UA 7WÛ # 8N g ± Fz 'ã . g
 $\alpha = \theta = . x ^ \circ " \delta_e = - x \times \div ! \text{æK} - \acute{O} \delta_{th} = ! . 0 "$
 £ † 'ã . 1 7bL • | D™ ÷ ! %
 = • Ö † ú 3âL • K) c

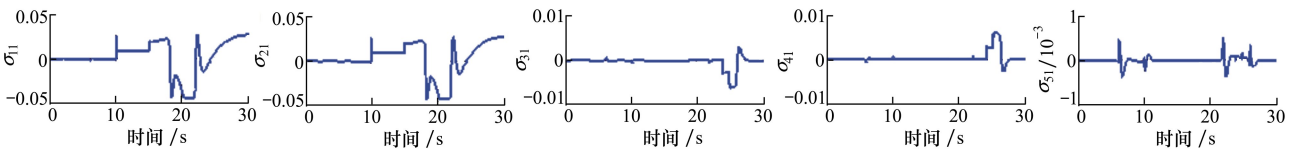
:/	r ÓK) c ð%po	EL(K) c ð%po% qß o
$\delta_{a7} " \delta_{a7r}$	- 0ß " ~ 0ß "	- ! ~ !
$\delta_{e7} " \delta_{e7r}$	- 0" ~ 0"	- ! ~ !
δ_r	- ! ~ !	- ß0! ~ ß0!
$\delta_{i7} " \delta_{i7r}$! 2 0"	q0" 2 0"



+ 0æ" =yg ± r KÉ8 " > ÿ æææææ+ æ" =yg ± r KÉ8 "\$ D™ ÷ æææææ+ xæ" =yg ± r KÉ8 " Ö#p> ÷
 ELÓ ú Á 3i ELÓ ú Á 3i ú Á 3i



+ "æ & t Kz7b | D™ 3i æææææææ+ æ & æ) | D™ 3i æææææææ+ @ææ>7b | D™ 3i



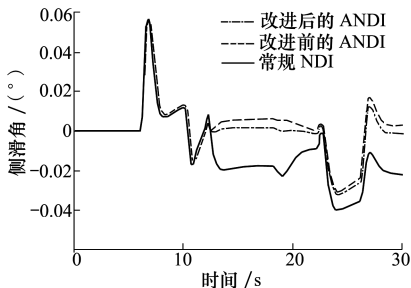
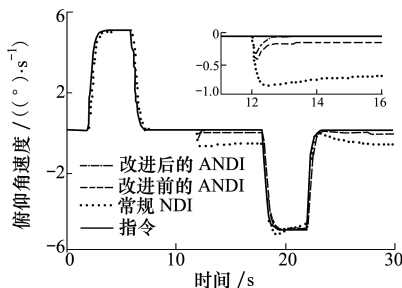
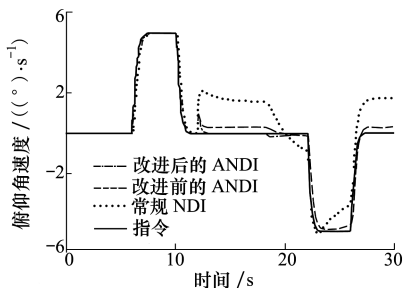
+ æf E ; ±3 â e • 7 E/ Á ,] @î i •

ææ • eN =y# " > ÿ ELÓ 1 \$ D™ ÷ ELÓ 6* L ELÓ ->] C CW 4 +æ" =y • ' (Ý r KÉ; " 3 â e

ææi 50N , ÷ 2(4 FôdM¼ g ß! @ " #K!
 KIKÁg T_s %ß Ž ß %Fô*U - Kc T(Ü7 ' N ú 3â
 L • ± " =yg ± " & » : 9 ú 3âL • ± r Ó ; EL(K) c
 æ ∈ - = • ß mg %
 ½ Ö † ú 3âL • " =yg ± r KÉ
 U e > î ± æ 7bL • Ž " | 1 æ 7buKz3Ö | r KÉ ÿ •
 8 " & m @ @ î Ö c • ± Q ÷ TE =yO1@î % 9 # 4 E
 Ä g S 6 4 \$ " ± > ÿ EL(' 1 \$ D™ ÷ EL(' 4
 " LK! ø 3ö . Ö # p > ÷ g L # %
 UN =yDö 8 Z " t @ è ß ! N g t Kz7b' (Ý r
 KÉ" r KÉ - Ä t Kz7b7buKz { 0! . +U ß " # N
 g t Kz7b Ž " U q | % U 0x 1 0" # N g &
 æ) Ö 3 X' (Ý T6* Kz3Ö r KÉ" r KÉ - Ä 7buKz
 { " ! . 1 " . % , ,L4 É - + 07 mg %

• 7 E/ Á, - ø ï ; A0i " ' "N g6* x : • Ö ž
 ú EL• : 7 =ž" £ A ; 4 >yELÓ Ê 6*Dë] L
 H±Ö. T6* "i WD88 , .g ' m@â! » f E ±±
 3 â e • 7 E/ Á Ö. E3Ô c • E.í ±±Qÿ T %
 ½#±Fúð/® ÿ •

Fúð z4\ N g±Fúð®i • x - "A C,! Ö
 ž ú] N g±ú3âT 1 Ö. T6* %Y <7 F UN g
 • Fúð/® ò • 8 &! O!@îm@â!f E ; ±±3 â



+ œFúð/® 8 "\$ DTYELO œœœ+ B œFúð/® 8 " >yELÓ œœœœ+ B œFúð/® 8 " Ô#p>ÿ
 ú Á&! 3i ú Á&! 3i ú Á&! 3i

œœœ &! 4 É6*,8 ' â• eN=y# " .ú Ö. E3Ô
 c • %U8 ±>yELÓ ú Á,%9 +s UFúð/® ; "e
 >nÖ. E3Ô c • T6* ...U ; k 8Kz%,%ú "f E z &
 ; ±7 E/ Á Ö. E3Ô c • 6* L x : Fúð/® EM=±±
 ž ú " @î• Ö 8>yELÓ ±±T6* "s f E ; ±±3 â e
 • 7 E/ Á Ö. E3Ô c • ±±ó→ T ! P "=•(Ý U>yEL
 Ó±±' .A ; k - <%j €7 ' ,8 " " » f E ±±
 3 â e • 7 E/ Á Ö. E3Ô c • 4 É: ò=•(Ý ' g T
 ±±Qÿ T "59A/® ' ³ ó→ TP ±±E%œ%

e • 7 E/ Á Ö. E3Ô c ±±T6* %
 9 d "4 N g S 6 4 \$ " ±± >yEL(' 1 \$
 DTYELO(' 4 " £ A>®o Ô#p>ÿ ø 3õ g L#% U B0
 #N g Fúð p*L/® " t @Fúð | / (µx %d ŽB] "
 µy %d ŽB] "µx %d ŽB] %&! f E z & 3 â e • 7
 E/ Á Ö " @â!±>yELÓ Ô c • 1 e>nÖ. E3Ô c •
 Ô c u É " &! 4 É - + 7 B m.g %

±4 ±@ç

Y ' ý ' - .ú ' » f E ++3 â e • 7 E/ Á Ö.
 E3Ô c æ" "U » ý P Ô c 2(4 ±±Qÿ T %, ,L4
 É=• ; " ' » ' æ" @â!yELÓ Ô c • U " =y g ±
 r KÉ' Fúð/® ÿ • 8 "=•(Ý ' ç \$ <±±Ô c
 T6* %

ï 50 ´ ([Á

B0œi ¶6ÄÄ i ö" 6¶¶i Öè" Hö••ö• Öü Ä" wUž¶•çz Uæzù çzç! :kdwù¶¶ !•çU üq ¶ U üü d& Uüüw. Öž•üçU
 •i Hü=Uüü •ç¶ Uü ÖfzU ü" B !" B"%oâ ®K x
 00œü ö¶¶H i " A¶¶ ý 6" @ P ê" wUžÈ 4& Uüüwüü w•U U üüüçz =üüçz] çw çzçz Uü f zU üüü çzçz . Öž
 .üçU •i Hü=Uüü •ç¶ Uü ÖfzU ü" O!B " x0%oâ B" B K8"
 Öœi çXêÄç ç è" èöA6Ä X Ö" A¶¶ ý öXê6¶ 6" wUžöç Uüü d¶¶çz] Uüç] çw&U) UqçUüü !•ç d çzçqç çzçz Uü
 ! :kdwù¶¶ üüçzçz] çw çzçz Uü f zU üüü çzçz . Öž •ç¶ 6çkç çkç èd¶¶üü " O!B " 0B%oâ B! " K! ®®
 x0œ6Äç ö>6 @•• çzçz . @¶ AEU " " ¶ö @¶¶ öžXü ž¶çzçz Uü Uüüü) f zU üüü çzçz Uqç = w Uk ç çü dfq çk
 •çzçz çzçz Öœöçö Hü=Uüü " ¶Uüüçzçz] Uüü •ç¶ •çzçz] O!B
 " Öœ• ÷ " !00! " † J È " 0v žf E . (3ü4-4 Ö. E3m7] Ô c æ" . Öžö A\$ /8 T " " Ö " O!B " %oâ B x K8 " x
 ; @ .üçzçz . ç¶¶H .üü _ d¶¶çzçz wUž Uüüçzçz f zU üüü çzçz Uüü çkç Uüüçzçz &U) •çzçz çzçz) çzçz çzçz w•ç
 . Öž .üçU •i @â!çzçz 6çkç çkç çzçz çzçz] O!B " %oâ B x K8 " x%ç dçzçz o
 Öœ9 %4TAE 0 ~ * ž' » - E Ô c ±± (3ü4-4 7 E/ Á N=yÔ c . Öžb v ; Ô c " O!B " B %oâ B K8®
 H6 _üçzçz ; @¶¶H üü çzçz ž çzçz Uüüçzçz &U) çzçz çzçz w•ç Uüüüü ! :kdwù¶¶ . Öž6 üüçzçz çzçz 2 •ç¶ "

