Lump Soliton Model on Chinese Microblog Public Opinion

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Abstract. There has been a tremendous rise in the growth of Chinese Microblog—Sina Weibo in the past few years. Sina Weibo contains many interesting hot issues. In particular, the trend of some hot topics can be described by the soliton wave model based on some hypothesis and parameter settings. The theoretical strategies to control the trend of hot topics are stated by employing the lump soliton solution theory of the KdV equation and KP equation.

1. Introduction
Chinese Microblog (Weibo) uses a format similar to its counterpart Twitter. Sina Weibo is the most visited such site in China which refers to mini-blogging services in China, including social chat sites and platform sharing. Weibos are a major source of commentary on a wide range of topics. Microblog public opinion plays a key role in spreading the news quickly and discussing and evaluating government response. Characteristics as immediate, fast, convenient and rapid spread of Microblog make that the Microblog public opinion is the most important one of the public opinions.

The research on Microblog public opinion has attracted a lot of attention during the past several years [1-6]. It is worth mentioning that the evolution and the control for the hot issues on Microblog public opinion is the main problem in the research field of Microblog public opinion [7]. We found an interesting phenomenon in the evolution of the hot topics—soliton waves by analyzing some specific examples[7]. Then we used the soliton model—non-local Davey–Stewartson equation [8,9] to describe the system and state the appropriate complete strategic classifications to control the trend of the hot topics on Microblog.

This paper is organized as follows. The next section deals with the Lump soliton waves in the development process of the hot spots on Microblog public opinion. The non-local Davey–Stewartson equation is introduced in section 3, which is 2+1 dimension model. The lump soliton solutions of Davey–Stewartson equation are also presented in this section. Section 4 is devoted to conclusions and discussions, such as the appropriate complete strategic classifications to control the evolution of the hot topics on Microblog public opinion.

2. Soliton Wave
Chinese Microblog ---Sina Weibo contains many trending topics. Three cases of the hot issues on June 27, 2017 attracted the attention. They are introduced as following.

Case 1. Yuyu Xu suffers fatal cardiac arrest after telephone scam. Yuyu Xu, an 18-year-old girl as a college-bound student, died after suffering a sudden cardiac arrest after funds her family had raised for her tuition fees were swindled in a telephone scam. She scored 568 points on her college entrance exam 2016 and was admitted to Nanjing University of Posts and Telecommunications. On Aug 19, 2016, Xu received a phone call from an unknown person notifying her that she was due to receive 2,600 RMB in student funding. Following the call, Xu wired a 9,900 RMB "activation fee" into the scammer's bank account, hoping the money would appear in her student account, but it never did.
After discovering they had been cheated, the family immediately reported the incident to the police, but Xu was said to be devastated. On their way home, she suddenly fainted and despite doctors' best efforts to revive her, she passed away.

Case 2. Chinese cities are saying “enough already” to bike-sharing services. For over a year, China’s city streets have been flooded with bicycles as dozens of start-ups vie to become the country’s “Uber for bikes.” One way to ensure that a potential rider always has a bike nearby is to put dozens of bikes on every street corner—but that has led to chaos and oversupply. For a while, local governments appeared powerless (or unwilling) to stop the mass of rubber and aluminum from blocking pedestrian walkways and piling up beside office complexes.

Case 3. China strengthens supervision of public funds deposit. China will strengthen supervision of commercial banks in deals of public funds deposit, to maintain a fair and orderly market, said the banking regulator in a statement on June 27, 2017. Authorities said employees of commercial banks should avoid personal relationships with public funds holders with deposits in their banks. The China Banking Association should urge its members to favor fair competition, avoid inappropriate deals and promote activities that complies with industry norms and practices.

We collected the newly added messages per hour on Sina Weibo from 04:00 AM to 16:00 on June 27, 2017. The followed table shows the data of the three cases.

|              | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|--------------|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Case1        | 6  | 35 | 130| 326| 371| 1163| 2162| 1668| 1287| 471 | 352| 424| 219|
| Case2        | 11 | 27 | 145| 289| 332| 651 | 1628| 2034| 2114| 1327| 683| 547| 201|
| Case3        | 1  | 3  | 39 | 88 | 559| 1354| 1987| 1087| 231 | 152| 149| 67 | 25 |

Denote time by t. Let the parameter u be the new messages per day. The figure is used to describe the variation of the three cases.

![Figure 1](image)

The Figure 1 tells us that every hot topic contains a special stage. This phenomenon is not infrequent. The special wave is called soliton wave. The soliton theory is one of the most important areas fields of mathematical physics. Today, soliton theory has multiple applications in plasma physics, matrix model of string theory, non-linear optics and light wave communication technology.

3. Soliton Wave

3.1. Assumptions
(1) The selected hot topics diffuse in a plane, i.e. the space of the evolution of the hot spot on Weibo contains two variables x and y;
The new daily messages about hot topics on Weibo will be zero when $t \to +\infty$. This assumption is reasonable and very important, and the reason will be further explained in the end of this section.

3.2. 2+1 Dimension Model
The 2+1 dimension model is non-local Davey–Stewartson equation introduced by Ablowitz and Musslimani [9] in the form as

$$\begin{align*}
iA_x &= A_{xx} - A_{yy} + (\epsilon V - 2Q)A, \\
Q_{xx} + Q_{yy} &= (\epsilon V)_{xx},
\end{align*}$$

(1)

where the constant $\epsilon = \pm 1$, component $Q$ is a transition function, function

$$V = A(x, y, t)(A(x, -y, t))^\dagger$$

(2)

and $A(x, y, t)$ is the amplitude of the wave of the hot topics as a function of three real variables, space $x$, $y$ and time $t$.

3.3. Solution of Davey–Stewartson equation
Following Hirota’s bilinear transform method for the integrable equations, we can employ the variable transformation as

$$A = \sqrt{2} \frac{G}{f}, Q = \epsilon - 2(\log f)_{xx}$$

(3)

to transform the Davey–Stewartson equation into Hirota’s bilinear form as

$$\begin{align*}
\left( D_x^2 - D_y^2 - iD_z \right) g \cdot f &= 0, \\
\left( D_x^2 + D_y^2 \right) f \cdot f &= 2\epsilon \left( f^2 - gh \right)
\end{align*}$$

(4)

The solution solution of Davey–Stewartson equation can be derived via Hirota’s bilinear transform method. The Davey–Stewartson equation has the N-th-order rational solutions as

$$f = \prod_{j=0}^N \theta_j + \frac{1}{2} \sum_{j<k} \alpha_{jk} \prod_{j \neq k} \theta_j + \cdots + \frac{1}{M!} \sum_{j,k,m,n} \alpha_{jk} \cdots \alpha_{mn} \prod_{p=1}^N \theta_p + \cdots,$$

(5)

$$g = \prod_{j=0}^N \left( \theta_j + b_j \right) + \frac{1}{2} \sum_{j<k} \alpha_{jk} \sum_{i \neq j,k} \left( \theta_i + b_i \right) + \cdots + \frac{1}{M!} \sum_{j,k,m,n} \alpha_{jk} \cdots \alpha_{mn} \prod_{p=1}^N \left( \theta_p + b_p \right) + \cdots,$$

(6)

where

$$\theta_k = \lambda_k x + iy + 2\gamma_k \frac{\epsilon}{\gamma_k^2 - 1} \left( 1 + \gamma_k^2 \right) t, b_k = -\frac{i\gamma_k}{\epsilon} \sqrt{\epsilon} \left( \gamma_k^2 - 1 \right),$$

(7)

$$\alpha_{jk} = \frac{\left( \lambda_j - \lambda_k \right) \left( \lambda_k^2 - 1 \right)}{2\gamma_j \gamma_k \sqrt{\left( \lambda_j^2 - 1 \right) \left( \lambda_k^2 - 1 \right) \left( \lambda_j^2 \lambda_k^2 - \lambda_j^2 - \lambda_k^2 + 1 \right) - \lambda_j \lambda_k + \epsilon}},$$

(8)

and $j, k \in Z$, $j, k \leq N$, $\gamma_j = \pm 1$, $\epsilon = \pm 1$, $\lambda_i$ are arbitrary complex constants. If we set $\gamma_j, \gamma_{j+1} = -1$, $\epsilon = -1$, $\lambda_j = -\lambda_{j+1} \neq 0, |\lambda_j| < 1$, we can obtain the non-singular lump solutions. A lump solution is a kind of rational solution which is real analytic and decays in all directions of the space. Setting $N = 6, \epsilon = -1, \lambda_1 = \lambda_2 = -\lambda_3 = -\lambda_5 = \frac{1}{2}, \gamma_1 = \gamma_2 = \gamma_3 = -\gamma_4 = -\gamma_5 = -\gamma_6 = 1$, $\lambda_3 = -\lambda_6 = \frac{1}{3}$, the equation generates a third-order lump solution. The trends of three hot topics are shown in the following Figure 2 which mean the time of the beginning as $t_1$ for 04:00 and $t_2$ for 07:00.
3.4. Application on Weibo

In this subsection, we turn back to the hot topics on Weibo. Based on the lump solutions of Davey–Stewartson equation, the following conclusions are worth to point out.

(1) The lump solution $A = \sqrt{2g/f}$ tends to zero when $t \to +\infty$, it is consistent with the assumption as the same as the evolution of the hot topics on Weibo. As we know, A is the variable describing the new messages per day. Indeed, the new messages about the hot issue on Weibo will be almost zero after a long time.

(2) Davey–Stewartson equation shares 3-soliton solutions, i.e. several solitons could coexist in the system at the same time. Weibo contains many hot topics. The three selected cases in section 2 all are soliton waves.

(3) We can read the time evolution of the three hot topics from the lump solution of the Davey–Stewartson equation. Actually, we have the time evolution of the lump solution as shown in the following Figure 3 corresponding $t_1$ for 10:00, $t_4$ for 13:00 and $t_5$ for 16:00 on June 27, 2017.

(4) The lump solution of Davey–Stewartson equation in the following Figure 4 can show the interaction of the three hot topics corresponding the intersection point in Figure 1 around the time 11:00 on June 27, 2017, when one wave overlap another one.
Figure 4. The interaction of the three hot topics

(5) From the soliton theory, the lump wave is once formed, and then it will continue for a period. This result tells us that the hot topics will keep be hot for several days normally.

4. Conclusion
To summarize, we have derived the theoretical strategies to control the trend of hot topics are stated by employing the lump soliton solution theory of the KdV equation and KP equation based on some hypothesis and parameter settings. The lump soliton solution shares 3-soliton solutions is first used for the evolution of the hot topics on Microblog public opinion. Soliton model in reference [7] shows only one 1-soliton solution. Based on the results, if we want to make the soliton wave disappear quicker than the normal, we could change the coefficients in the lump solution to break the balance between. Therefore if we want to control the tendency of the hot topics, For example, to make the hot topic be not hot, we have to break the balance between the losing consumers and the added new consumers of the hot topics on Weibo. It is the theoretical base to control the trend of hot issues.

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